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The Institute of Vitreous Enamellers

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and

The Foundry Trades' Equipment and Supplies Association

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The Factory Report

As was generally anticipated, factory accidents showed an increase in 1936 over 1935, obviously due to increased industrial activity. The actual figures were 18 per cent. for accidents generally and 9 per cent. for fatalities. Mr. D. R. Wilson, the chief factory inspector, is rightly disturbed over the number of serious accidents which have occurred to young people, and of a dozen or more cases of serious accidents, many fatal, which could have been prevented by better supervision, fortunately none occurred in the foundry industry.

The Report this year contains none of those hints from which one can usually forecast the trend of future legislation, due no doubt to a laudable desire not to prejudice discussion on the major consolidation Bill now passing through Parliament. In Mr. Macklin's Report on Safety, attention is drawn to a widely-held idea that it is best to await a visit from the factory inspector before fencing a machine in order to have the benefit of his experience. This must not be done, and as it will be the duty in the future of the supplying firm to fence all machinery, this custom should disappear.

Mr. W. E. Harding has contributed a chapter on accidents to young persons and this emphasises the real need for special supervision during the first few weeks of employment. Between a quarter and a third of the accidents are placed to the responsibility of the employer, while the young persons were themselves to blame for between 40 and 50 per cent. Many of these injuries are slight, but their total is high in relation to the total number of persons employed. Various reasons are assigned for this, such as scarcity of juvenile labour, which forces the employers to set on an inferior type, or none at all, and modifications of manufacturing processes which make possible the employment of young persons; the example quoted is the extended use of core-blowing machines in foundries. Other causes cited are inappropriate bonus schemes on production, inclination of youngsters to take off time and so convert a minor mishap into a reportable accident and mental anxiety due to domestic troubles. Dr. J. C. Bridge, in his report on health, includes a table on lead poisoning which shows that vitreous enamelling has caused five cases, against only one in 1935, but the position is much more satisfactory than before the war. Another table deals with silicosis, but the figures cover the period from 1929 and the nature of the disease precludes annual dissection. In the Report it is regretted that there are definite indications of a return to sand for blasting and the author is convinced that such an action is unnecessary, except in very exceptional cases.

In the foundry section of the metal industry, there were 11,123 accidents of which 38 were fatal. Of these fatal accidents, falling down and being struck by falling bodies together account for 15, and lifting machinery for another eight. Molten metal accounts for two only. Of the non-fatal accidents this factor of being struck by falling bodies amounts to over 1,300. Surely this figure could be reduced? Other major items are burns, handling goods in various ways and in the use of hand tools.

The Scrap Campaign

The campaign instituted by the British Iron and Steel Federation for the collection of scrap is in full swing, and it is well that the facts of the scrap situation should be generally understood. Nearly six months ago the Federation and the National Federation of Scrap Merchants arranged a voluntary agreement stabilising scrap prices, and excluding the export of scrap after contracts in force were completed. Four of the largest steel firms in the country act as buyers of scrap on behalf of the firms in the B.I.S.F., and they buy most scrap available at the agreed prices. An international agreement also exists between ten countries, by which each country reserves its own scrap for its own use. Thus any scrap available for sale outside the agreement negotiated between the two federations would readily find a foreign buyer. The price of scrap here is, of course, less than can be obtained from certain foreign countries, which, lacking their own resources in ore, are compelled to rely on scrap purchased from abroad. The influence of this on export prices has been significant. In 1935 the value of exported scrap was approximately 50s. per ton; in 1936, approximately 58s. per ton, and this year it has been 72s. per ton. It is hoped to reduce the export of scrap from this country to a very small figure by voluntary agreement, although it has been found necessary in France, Germany and Belgium to prohibit scrap export, and an embargo is talked about in the United States. The control in the home trade clearly breaks down if unlimited export is allowed, and by one method or another it should clearly be stopped. During the first six months of the present year scrap was leaving our shores at the rate of six to seven thousand tons a week, something like a third of the total scrap demand of the founding industry, or more, assuming that its retention would release from other consumers usable scrap for the foundry.

Notes from the Branches

East Anglian Section.—On July 21 members were invited by Mr. T. Reavell to visit the foundry and works of Laurence, Scott & Electromotors, Limited, of Norwich. Mr. T. Reavell had arranged so that the maximum number of moulds remained open in the foundry, and this allowed the visitors to obtain a good idea of their construction and the shape and disposition of the cores. The dried sand cores were of particular interest, because of the starch binder used in them. It was learned that by use of the starch binder no new core sand is ever required. The spent sand is simply conveyed from the shake out and reconditioned by the addition of the starch residue.

Besides the grey-iron foundry there was a section devoted to the founding of gunmetal and aluminium castings. Subsequent to the tour of the foundry the visitors were entertained to tea in the very spacious works canteen.

Mr. L. Tibbenham (Section President) moved a vote of thanks to Mr. T. Reavell and Capt. Scott. He was supported in this by Mr. J. L. Francis, to which both Mr. Reavell and Capt. Scott replied.

During the coming session of autumn and winter lectures a joint meeting has been arranged to take place at Norwich with the Norwich Engineering Society, and it is largely due to the interest and effort on the part of Mr. T. Reavell that such a desirable arrangement has been made possible.

A Large Planing Machine Casting

The Egglescliffe Foundry, a section of the Head, Wrightson organisation, whose main works are established at Thornaby-on-Tees, have recently completed what is believed to be the largest iron casting ever manufactured by the company, who have been ironfounders for almost a hundred years.

The casting, which weighs 40 tons, is one section of a table for a planing machine, and as an indication of the intricate design of the job there were 160 cores used in moulding operations. The casting was of such abnormal dimensions, being close on 40 ft. long and over 9 ft. wide, that special traffic arrangements had to be made for its conveyance to Scotland, there being several places on the route with only inches to spare.

A 40-TON SECTION FOR A PLANING MACHINE MADE IN CAST IRON.

This casting is part of an order for six cast-iron tables, for planing machines, each table comprising one casting weighing 40 tons and one weighing 18½ tons. Head, Wrightson & Company have excellent facilities for undertaking this class of work, as will be indicated by the fact that the closing of the mould for casting was commenced on June 21 and completed on Thursday, June 24.

Book Reviews

Creep of Non-Ferrous Metals and Alloys. A Review of Published Information. By W. A. Baker, B.Sc. Research Report R.R.A. 449 of the British Non-Ferrous Metals Research Association. Published by the Association, Regnart Buildings, Euston Street, London, N.W.1. Price 2s., post free.

It has long been recognised that metals undergo slow deformation (creep) when subjected for prolonged periods to high temperatures and stresses, but systematic investigations of the phenomenon have been conducted only in comparatively recent years. At the present time extensive studies of the creep characteristics of materials are in progress, and engineers are adopting the data obtained, as a basis for design, in place of those derived from tests of short duration.

The object of the present publication is to summarise the available published information relating to the creep characteristics of non-ferrous metals and alloys. The data presented have been selected critically, and include information on copper and copper alloys, nickel alloys, aluminium and aluminium alloys, and lead. In the case of aluminium, some results in the "as-cast" condition are given. The numerical values are set out in tabular form convenient for reference, with compositions of materials; each table is followed by a list of Papers on which the data are based, with a note on the contents of each Paper. An index to all metals and alloys mentioned is supplied.

Stock Exchanges. Ten-Year Record, 1927 to 1936 Inclusive. Compiled by Fredc. C. Mathieson & Sons, 16, Copthall Avenue, London, E.C.2. Price 20s.

The "Stock Exchanges London and Provincial Ten-Year Record of Prices and Dividends"—a comprehensive title which tells its own story—has now been published on no fewer than twenty-nine occasions. Into each successive issue has gone all the experience and all the pooled knowledge of the compilers, so that the present volume with its 580 pages packed with thousands of facts and figures is worth much more than the published price. Further, the prices and the dividends are as accurate as is humanly possible.

One feature that will be welcomed by those who pay sur-tax and who are entitled to income tax relief is that (with the exception of the mining portion) every variable dividend is generally set out with the approximate time of payment. Again, the highest and the lowest prices are so arranged that they can be determined instantly.

Altogether, this is a volume that is at once a mirror of trade and an invaluable guide for anybody interested in stock exchange dealings.

B. H.

Random Shots

When writing last week of the Scrap Iron luncheon staged by George Cohen, Sons & Company, Limited, "Marksman" unfortunately forgot that many English people feel much more at home with Hindoo, Urdhoo, Pushtoo, and other such remote languages than they do with a menu written in French. Brave souls who would never turn a hair when face to face with a lion in darkest Africa, turn pale at the sight of a restaurant menu! Thus it has happened that he has been snowed under with requests for a translation of last week's menu. It is, indeed, a pleasure to give one, for it at least gives "Marksman" an opportunity to say "Yah!" to the member of "The Times" staff who as much as confessed that the subtleties of the metallurgical allusions were beyond him! So here is an English version:

Melon Roundoaks.—A compliment to Lord Dudley.

Salmon à la Steelhouse.—The recently opened headquarters of the Iron and Steel Federation.

Blooming Sauce (on the part of whom?).

Scrap Merchant Chicken (there ain't any such animal. They're all tough old birds).

York Ham.

Soft Tongue.—A hint to the after luncheon speakers?

Corporation Galantine.—The Iron and Steel Corporation.

Scrap Salad.—It is to be hoped that the caterers didn't understand, either.

Chilled Iron Ices.

Thin Sheet Wafers.

Petits Fours Martin—the "fours Martin" being the Siemens furnace and the petits fours being those delightful little sweetmeats so dear to the English.

* * *

One of the brighter Dailies, by the way, reporting this luncheon, said that it was "all a little joke on the part of Mr. George Cohen, a scrap merchant." This has the same flavour as the story of the great Mr. Hearst, who, when on a visit from America, wished to buy himself a new hat. Walking into the shop of Henry Heath, Limited, he said to the young salesman: "I'd like to see Mr. Heath, please." "Oh, so would I," replied the Y.S. "What do you mean by talking like that to me?" demanded the irate Mr. Hearst, "Get busy." "Well, sir, pardon me, but it's like this. Mr. Heath has been dead these hundred years."

* * *

Next Monday will be the August Bank Holiday. If every driver who breaks the rules of the Highway Code were made to forfeit his car in the cause of the National Scrap campaign, the scrap heaps would swell considerably and the roads be more comfortable places for the few motorists that would be left. As it is, everyone using the Southend road or the arterial road to Blackpool on that day might trail a magnet behind his car and see what scrap he can collect with the minimum of effort.

* * *

Aluminium is indeed proving to be a very versatile metal, for from Germany comes news of its use as a new constituent of an old liqueur known as "Geltwasser." How much more pleasant it would be for silicosis-prone workers to take a glass of "Geltwasser" after lunch instead of having to digest a meal of aluminium-typed sheets of rules and regulations.

* * *

The task of deciding on a suitable holiday should not be difficult. Whilst politicians invariably go to the country, it is obvious that foundrymen will feel at home where the sand is, and how the old-timers will love mixing beer with the sand!

"MARKSMAN."

American Sand Testing Technique*

By EARL WOODLIFF

With many types of testing machines available to-day, sand control is taking its place of importance with metallurgical supervision in the foundry. Combining the records with technical experience and judgment, the foundry is fast rising from its rule of thumb methods. Moulding sand is the foundryman's greatest tool. However, it is one of the greatest handicaps when careful control is not exercised over its many variable properties. The purpose of sand control is to obtain, and then maintain, a

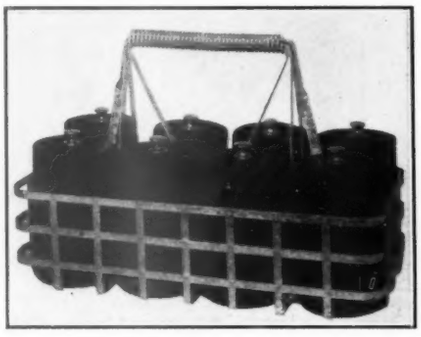


FIG. 1.—SAND SAMPLE TRAY WITH LIGHT CONTAINERS.

desirable moisture content, permeability, green and dry strength, detormation, clay content, fineness, expansion and sintering point.

Sampling

The first consideration in sand control is the selection of a representative sample of the sand to be tested. In foundries where the sand is on the floor each heap or floor should be numbered. All batches of mixed facing should also be given a number. In foundries where sand is handled on conveyors, it is a common practice to letter each conveyor unit.

Sand samples should be collected from at least three points of the sand heap in the case of floor moulding, and at least once each hour from the conveyor going to the moulding stations in conveyor moulding.

At least a quart sample of sand should be secured from the front, centre and rear of each floor and sealed in a container to prevent loss of moisture. A set of eight such cans is marketed with a suitable tray for conveying, forming a convenient means for collecting the sand samples (Fig. 1). Each sample should be riddled through a quarter-inch mesh screen and tested within 15 minutes after collection. Dry strength may be determined once each week, while the fineness test may be made once each month or oftener if required.

Sand test data should be recorded in order to check against casting conditions and filed for future reference, thus forming a useful means of answering questions pertaining to sand conditions in the past when certain casting conditions exist. If sand is on the floor it is desirable to test at the time the sand is cut. This is to determine the proper moisture content for the man wetting the sand. If the sand is cut at night then the sand tester should work at night. This gives to the mixing foreman, moisture content, bond and permeability, for the foundry foreman to start out the day.

Moisture Control

Whether the sand is natural or synthetic it remains the foundryman's task to add water. The amount needed or its total content determines the sand's practical value, and is the most important step in preparing the sand for moulding. Moisture determinations at the rate of one per minute can be made with the use of the "Moisture Teller," as compared with one hour by oven drying. Both are accurate standard methods of moisture determination. This Moisture Teller (Fig. 2) may be placed at the tempering station, conveyor system or in the sand laboratory wherever electrical current is available.

The sample of 50 grams is sufficiently large to give an accurate test. Heated air is passed through the sand, flashing the moisture to steam, and is carried out through the 500 mesh Monel metal filter cloth.

Varying moisture results in washes, low dry-strength, and brittleness when the sand is dry. Excessive steam, deformed parting line, blow holes, low permeability, poor casting finish are the results of high moisture. Proper moisture for any moulding sand is termed "temper moisture," and is that moisture content which gives the proper plasticity to the bonding material being used, resulting in maximum strength, smoothest casting finish and highest production. This point must be arrived at for each foundry floor by comparing test figures with scrap casting data and production.

Permeability

Permeability is the rate at which sand will permit air to pass through it. It is measured by ramming up specimens of sand two inches high and two inches in diameter with the A.F.A. standard rammer (Fig. 3) or three blows with a 14-lb. weight falling two inches. The permeability number is the number of millimetres of air that will pass through one millimetre

FIG. 3.—A.F.A. STANDARD RAMMER WITH SPECIMEN TUBE, PEDESTALS AND STRIPPING POST.

of sand per minute at one grain pressure. Permeability readings are in direct relation to openness of sand, thus a 40 permeability is one half as open as an 80 permeability.

In preparing the sample for permeability and strength test it has been found best to use a weight sample, the weight of which must be determined for the different finenesses of sand and has been found to be from 155 to 175 grams for most foundry sands. After placing the sand sample in a specimen tube, a second pedestal is placed on top of the tube, and the tube and pedestal are inserted once or twice to ensure a uniform density before ramming.

The sand rammer is part of the permeability testing equipment. The rammer head is tapered and hardened to prevent binding and reduce wear. It is important that the rammer has a solid mounting inasmuch as the sands are sensitive to ramming. Specimen tubes are made with extra heavy walls to resist bulging and are hardened to resist wear. Under continuous use, however, they may change their size and shape. Worn tubes tend to tear the specimen when

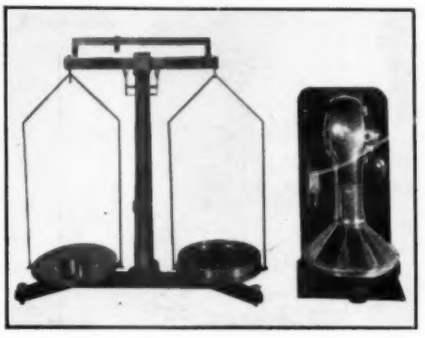


FIG. 2.—BALANCE AND MOISTURE TELLER.

it is stripped, resulting in inaccurate strength test. It is recommended that a standard tube be kept in the laboratory to check production tubes at least once a week.

The inserted specimen tube and rammed sand sample are placed in the mercury seal cup of the permeability meter (Fig. 4). This may be compared to the cope of a mould, air pressure being exerted on the sand by a weighted floating air-drum and controlled by a gold lined orifice. The readings are taken direct from the scale by rotating to the height of the water in the monometer tube and one test is easily made in 10 seconds.

The orifice method of permeability is sufficient for shop control and must be checked periodically by the stop watch method. The permeability is given by the following formula:—

$$\text{Perm.} = \frac{501.2}{\text{Pressure (from pressure scale)} \times \text{Time (min.)}}$$

Other permeability readings are made on this machine by use of simple adapters for holding the standard specimen, such as base permeability screens for dry, clay free core sands. This is obtained by placing a screen in the bottom of the specimen tube and ramming up a two-inch specimen of the sand to be tested and placing a second screen on top of the specimen. Permeability of baked core sand is obtained by clamping a standard two-inch baked core specimen in the core permeability tube and placing mercury to form an air tight seal around the core. The two above permeabilities are then taken in the same way as for green sand.

The permeability of baked cores is very desirable for large cores and thin wall castings to assure both rapid escape of the gas and heat penetration to disintegrate the core. Excessively high permeability is dangerous, as it allows metal penetration into the core or rough cored surface.

Strength Test

Second in importance to moisture control is the control of the bond or strength of the sand. Much of the foundry scrap is traceable to improper control of the green and dry strength of the sand as well as poor production due to lost moulds.

D

* A Paper read before the New England Regional Foundry Conference. The author is engineer to the Harry W. Dietert Company.

The universal sand strength machine is a dead weight testing machine in which the standard A.F.A. specimen is placed and broken (Fig. 5). The strength is recorded by a magnetic rider reading directly in pounds per square inch.

Care must be exercised, when operating this machine, in placing the specimen between the testing jaws. The jaws must be brushed clean and the machine kept level. The loading of the specimen must be uniform and continuous. In hand operations 20 revolutions of the hand wheel per minute is good practice. This

FIG. 4.—PERMEABILITY METER.

machine is also equipped with motor drive, which is recommended when more than one operator is required to use it.

The green strength of a sand may best be controlled by establishing a uniform daily addition of new sand or bonding material. The quantity of new material added is adjusted when required in order to maintain an established green strength. The dry strength of the sand may be controlled by selecting a new sand, clay or bentonite which possesses the dry strength property desired.

The strength of the sand can be expressed in either shear-tensile or compression. However, the latter has gained preference due in part to the higher readings obtained. Shear strength of the moulding sand is not so readily affected by moisture changes.

The strength machine is made universal by the several attachments which are readily attached to it. These are the tensile strength for green sand; tensile grip-jaws for testing the baked strength of cores; high dry-sand strength for testing dry-sand-strength of moulding sand over 250 lbs. and a deformation and resilience accessory for testing the deformation or "shortening" of the green sand specimen under load.

Recent work on deformation control has produced some rather important facts. Since deformation is the plasticity of the bonding material or measure of the brittleness of the sand, it bears a direct relation to the moulding qualities of the sand. Deformation is measured in thousandths of an inch decrease of length per inch of length of the sand specimen. Deformation of a new strong bonded moulding sand may be as high as 0.08, and for weak low moisture it may be as low as 0.003. Deformation of the sand is affected by hard ramming, varying moisture, coal-dust and clay content. Working limits of the deformation of moulding sand have been set at 0.007 to 0.012 per inch of length.

Low deformation results in swells and crushes. Low production due to broken moulds is often the result of low deformation inasmuch as the sand is brittle and not capable of deforming sufficiently for deep draws or irregular pattern contour.

Deformation of moulding sand is controlled by the moisture content and the condition for which it is used, namely, hardness of the mould. High deformation is the result of too high moisture or high percentage of plastic bond, both of which result in high mould hardness when ramming of the mould is not carefully controlled. High deformation combined with high mould hardness result in high expansion or "buckling" of the sand when subjected to the temperature of the metal.

Resilience of sand is the expression of the work required to break the sand or being equal to deformation in thousandths of an inch multiplied by compression load at breaking times one thousand. The working limits of resilience are tentatively set at 50 to 110. As an example the following is given:—

$$\text{Resilience} = 0.010\ (\text{Def.}) \times 7.5\ (\text{Comp.}) = 0.075 \times 1{,}000 = 75$$

The hardness of the mould may be quickly measured by the mould hardness tester. This test is similar to the Brinell hardness of iron inasmuch as it measures the depth of penetration of the ball point. Mould hardness should be controlled to suit the design of the pattern and is recommended between 50 and 60. Mould hardness should be checked by the foreman and correlated with scrap data.

Fineness Test

Fineness test of the moulding sand should be checked at least once each month and is made by separating the sand and clay. First the sand grains are scrubbed clean of clay substance in a solution into which caustic soda has been added. By intermittent settling and syphoning the clay substance is removed. The loss and weight of the original sample are then expressed as per cent. of clay substance. The remaining dried sand grains are then placed on the upper sieve of the A.F.A. sieve series. These sieves are then shaken for 15 minutes and grains retained by each sieve are expressed in per cent. of the total original sample. Grain distribution is that range in which the sand grains distribute themselves. Grain distribution can readily be made more useful if the per cent. retained by each sieve is plotted against sieve size on squared paper. The fineness of moulding sand can best be controlled by testing deliveries of new sands and buying sands to fineness specifications.

Sintering Test

The sintering point of moulding sand is that temperature which the sand starts to fuse and is obtained by laying a platinum ribbon across the A.F.A. dried specimen, then heating up the ribbon by passing current through it. The temperature of the ribbon and sand is measured by an optical pyrometer. The sand is heated for three minutes and allowed to cool. The ribbon is lifted and note is made if the sand is fused to it. Tests are started low in the neighbourhood of 1,150 to 1,200 deg. C. Temperature increases are made by steps until the sintering point is reached. Factors affecting the sintering point of sand are its grain size, mould hardness, kind of clay and percentage of fluxes, such as calcium, etc. A high sintering point does much to improve casting-finish, and will aid the sand to strip cleanly from the casting. As an example, non-ferrous metals poured below sintering point strip cleanly from the casting. Most

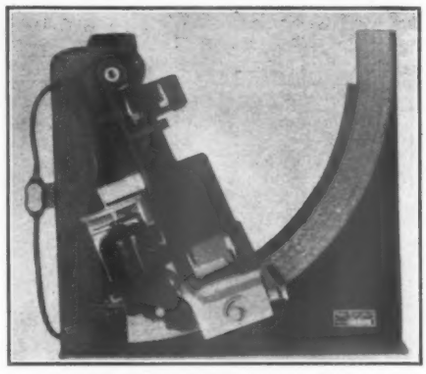


FIG. 5.—MOTOR-DRIVEN SAND-STRENGTH TESTING MACHINE.

ferrous metals are poured at or above the sintering temperature of the sand, therefore some burning in will result unless the mould is protected. Research work is being conducted on other properties of sands at elevated temperatures. At the present time the data are incomplete, but show what the future holds for sand testing.

Conclusions

(1) Records of tests, available for comparison with castings produced, scrap losses and production, such as broken moulds, should be kept at all times.

Form 69

UNITED STATES RADIATOR CORPORATION

SAND CONTROL TEST SHEET

PLANT TESTED BY DATE

SAND DATA — TO BE FILLED IN BY SAND TESTER												FINISHED CASTINGS — TO BE FILLED IN BY FOUNDRY FOREMAN		
FLOOR NO.	PERMEABILITY F	PERMEABILITY C	PERMEABILITY R	STRENGTH F	STRENGTH C	STRENGTH R	MOISTURE F	MOISTURE C	MOISTURE R	SACKS SEA COAL	BARROWS NEW SAND	REMARKS	PATTERN NO.	FINISH	REMARKS

Coal dust is the English equivalent of "Sea Coal" referred to in Column 5.

FORM A.

FOUNDRY SAND TEST DATE

UNIT					UNIT					UNIT					
TIME	MOIST	PERM.	BOND		TIME	MOIST	PERM	BOND		TIME	MOIST	PERM.	BOND		REMARKS

FORM B.

(2) Compare tests of the best floor or system sands by setting up the test figures which produce the best results, and maintaining or working to these standards as a basis for instituting sand control. This eliminates many variables directly traceable to moulding or core sand.

(3) Number each floor or system, and keep records of each on suitable forms (see Forms A and B), one of which should be in the superintendent's office at the end of each day, so

(*Concluded on page* 85.)

Gear Castings with Special Reference to Cast Iron

By OLIVER SMALLEY

(*Concluded from page 65.*)

Mass Influence

Besides its inherent low strength, an outstanding objection to cast iron for gears is mass influence in further reducing the strength values and in causing an openness of grain at the root of the teeth. This is illustrated by Figs. 13, 14 and 15. Here a series of Brinell hardness test values are shown through the centre of a number of castings, 2, 4, 6, 8, 10 and 12 in. thick.

Fig. 13 was made in a good grade of cast iron of the following composition: T.C, 3.42; C.C, 0.73; Si, 2.16; Mn, 0.83; S, 0.090; P, 0.144 per cent. Fig. 14 is an alloy cast iron made from a high steel-mix of the following chemical composition: T.C, 3.3; C.C, 0.78; Si, 2.00; Mn, 0.72; S, 0.078; P, 0.102; Ni, 0.81; Cr, 0.20, and Mo, 0.38 per cent. Fig. 15 is "B" Meehanite and has the following composition: T.C, 3.10; C.C, 0.75; Si, 1.10; Mn, 0.70; S, 0.114, and P, 0.095 per cent.

No. 4 grey cast iron shows a rapid drop in hardness from 207 on the 2-in. section to 170 on the 4-in. section, also the hardness variation from the outside to the centre of these specimens is excessive. Fig. 14—alloy iron—shows the same trend as cast iron but to a lesser degree, and Fig. 15—B Meehanite—shows very little loss in hardness as the casting dimension increases, but what is more important, it gives a uniform hardness and density in castings of any one section.

The hardness values from each series of tests are shown below the test blocks graphically and an examination of these curves reveals that what variations recorded in even the 12-in. section casting of Meehanite is so small as to be within the limits of experimental error.

In order to obtain further information of mass influence on strength values, a number of Meehanite foundries made tests on bars 0.75, 1.2, 2, 3, 4 and 6 in. The average results are given in Table VI.

At 3 in. the ordinary cast iron has lost almost half of its strength, and at 4 in. and 6 in. the strength values were well below 4.4 tons per sq. in. The Meehanite has retained practically full strength at 3 in. and 90 per cent. at 6 in.

These tests amply portray Meehanite is not influenced by mass action in the way that cast iron is, and that in designing assurance is had that every square inch of cross section carries its full share of load and that gear teeth will be uniform in both strength and wear properties.

TABLE VI.—*Tensile Strength in Relation to Section Thickness.*

Section of casting tested. In.	Tensile tons per sq. in.	
	Grey cast iron.	Meehanite.
0.75	12.3	—
1.25	11.5	23.9
2.00	8.2	24.2
3.00	6.8	23.7
4.00	—	22.7
6.00	—	21.2

Applications

Combining wear, toughness, strength, low coefficient of friction, dampening vibration, assuring uniform properties whether cast in light or heavy sections and machining freely even at Brinell hardness values up to 300, Meehanite is a useful and economical material for cast-to-form cut gears, spur, bevel and worm gears. Meehanite gears are giving excellent service in many varied industries, including machine tool, steelworks equipment, overhead travelling cranes, heavy engineering machinery, paper and cement mills, etc.

Accuracy and Noiseless Application

Absence of internal strain, low coefficient of friction, uniformity of structure and density throughout all sections are qualities of Meehanite that assure extreme accuracy, quiet and smooth operation. An installation of a Meehanite gear on a dividing engine built by the National Tool Company is a typical example. The gear was 60 in. and the tooth spacing was held to a 0.0002 in. limit. Gears for pumps made in heat-treated A Meehanite to specified 300 Brinell hardness are shown by Fig. 16. The fit is close and must remain close under continuous service operations.

C. H. & E. Manufacturing Company in a gear test on their No. 11 Triplex Pump, which pumps

n2

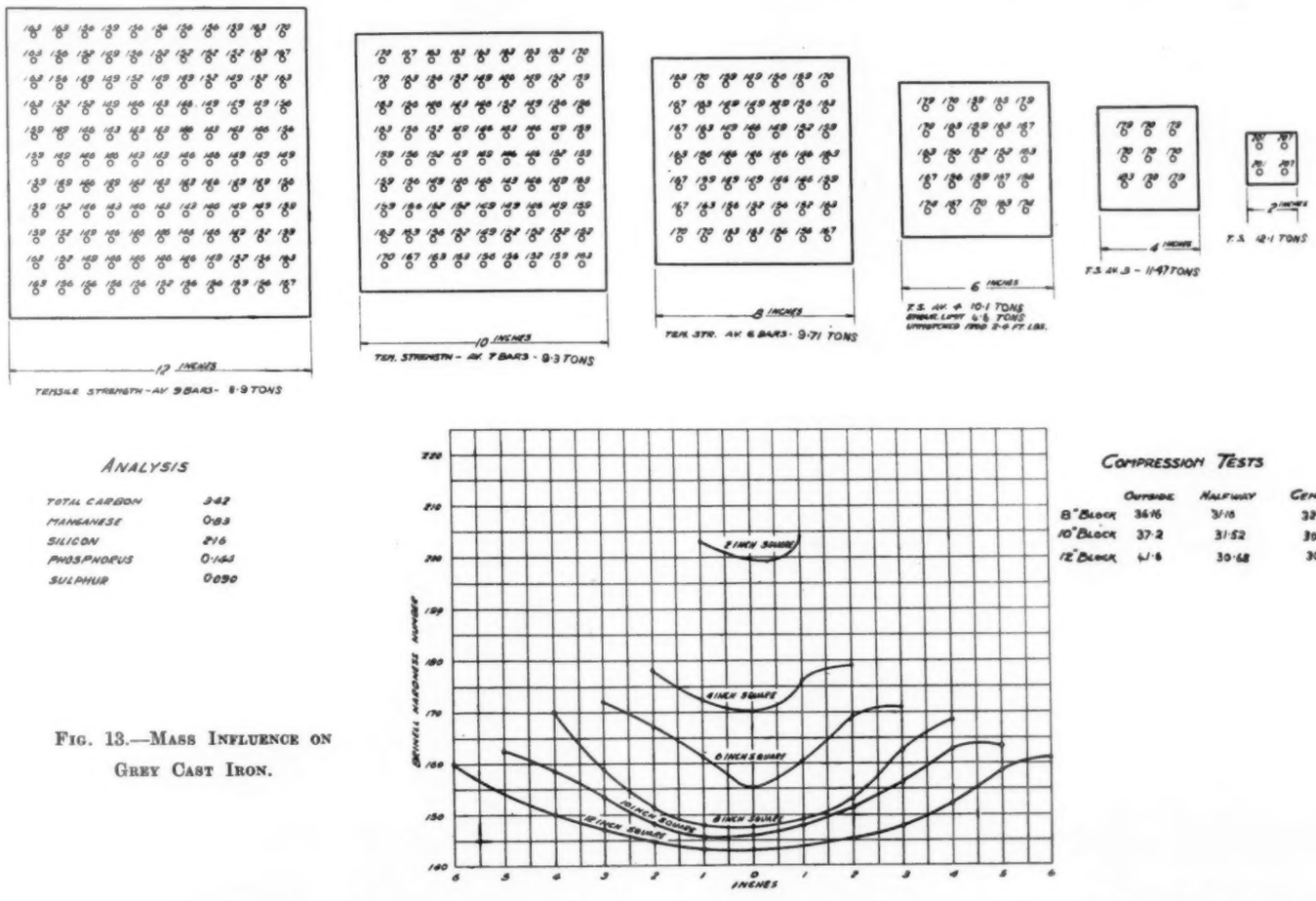
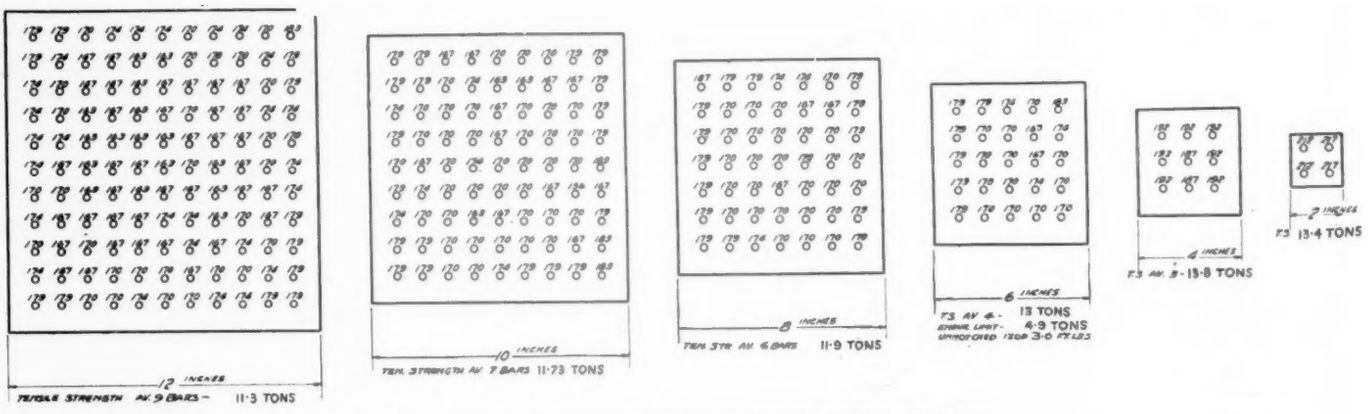
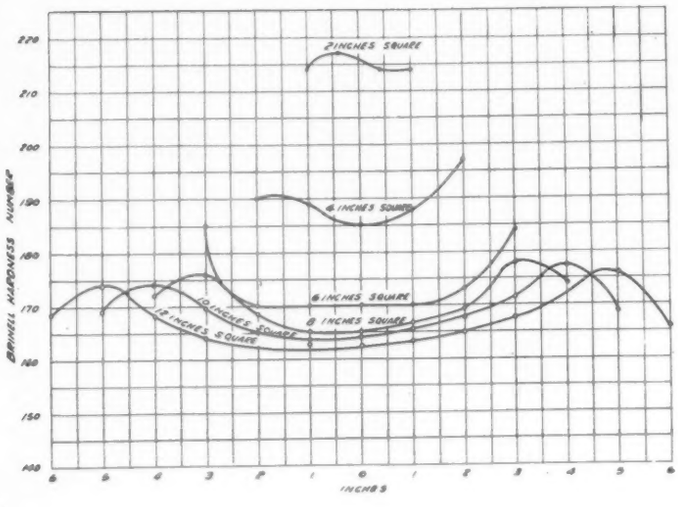


FIG. 13.—MASS INFLUENCE ON GREY CAST IRON.


12 INCHES
TENSILE STRENGTH AV. 9 BARS – 11·3 TONS
10 INCHES
TEN. STRENGTH AV. 7 BARS 11·73 TONS
8 INCHES
TEN. STR. AV. 6 BARS 11·9 TONS
6 INCHES
T.S. AV. 6 – 13 TONS
ERRATIC LIMIT – 4·9 TONS
UNNOTCHED IZOD 3·0 FT. LBS.
4 INCHES
T.S. AV. 9 – 13·8 TONS
2 INCHES
T.S. 13·4 TONS

ANALYSIS

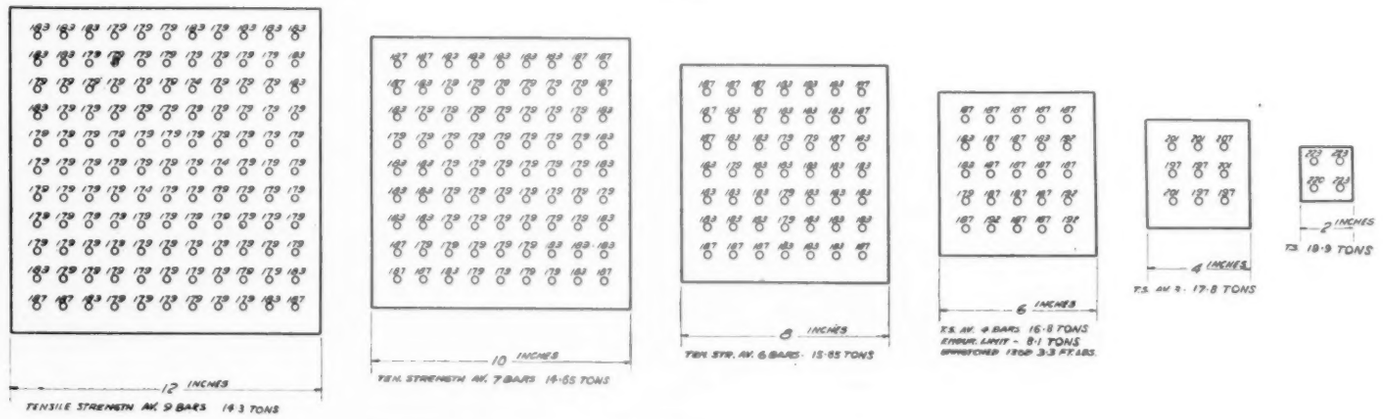
TOTAL CARBON	3·30
MANGANESE	0·72
SILICON	2·02
PHOSPHORUS	0·102
SULPHUR	0·078
NICKLE	0·81
CHROMIUM	0·20
MOLYBDENUM	0·38



COMPRESSION TESTS

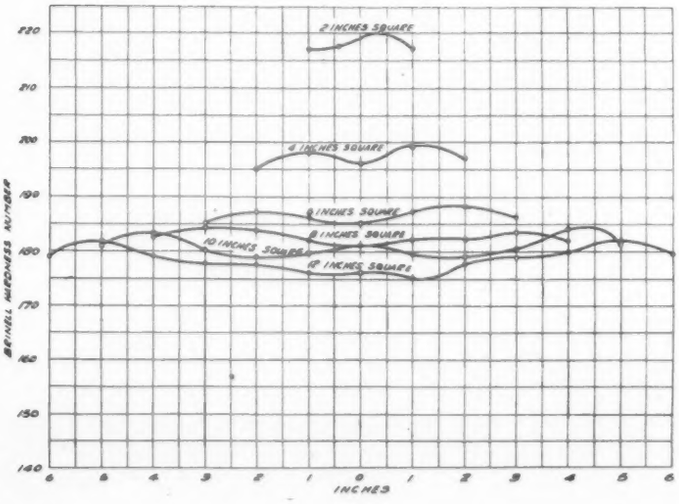
	OUTSIDE	HALFWAY	CENTRE
8" BLOCK	43·06	37·59	38·38
10" BLOCK	43·3	37·77	36·61
12" BLOCK	42·38	37·7	36·9

FIG. 14. — MASS INFLUENCE ON ALLOY CAST IRON.


12 INCHES
TENSILE STRENGTH AV. 9 BARS 14·3 TONS
10 INCHES
TEN. STRENGTH AV. 7 BARS 14·65 TONS
8 INCHES
TEN. STR. AV. 6 BARS 15·85 TONS
6 INCHES
T.S. AV. 6 BARS 16·8 TONS
ERRATIC LIMIT – 8·1 TONS
UNNOTCHED IZOD 3·3 FT. LBS.
4 INCHES
T.S. AV. 9 – 17·8 TONS
2 INCHES
T.S. 18·9 TONS

ANALYSIS

TOTAL CARBON	3·00
MANGANESE	0·80
SILICON	1·54
PHOSPHORUS	0·080
SULPHUR	0·101



COMPRESSION TESTS

	OUTSIDE	HALFWAY	CENTRE
8" BLOCK	43·75	49·2	49·28
10" BLOCK	50·8	48·3	47·15
12" BLOCK	50·79	47·41	46·25

FIG. 15. — MASS INFLUENCE ON MEEHANITE METAL, PROCESS B.

80 galls. per min. under 500 lbs. pressure or 125 galls. per min. under 320 lbs. pressure, found that when steel gears were used, these pumps working under such extremely high pressure, gave considerable trouble as they were continually pitting on the face of the teeth. The test run of the Meehanite gear was fourteen days on the test floor under 600 lbs. pressure on a 500 lbs. rated pressure pump. The pump then went into the field and after ninety days under actual field conditions was returned to the shop for examination and it was reported that the gear teeth showed no trace of wear, but merely had a high mirror-like polish. There was no trace of pitting.

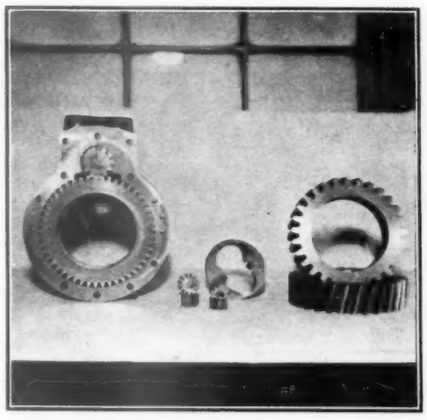


FIG. 16.—HEAT-TREATED CAST-IRON PUMP GEARS.

Many machine tool companies, such as Cincinnati Milling Machine Company, Cleveland Planer Company, have adopted Meehanite gears on account of their trueness and their accuracy in service, and, moreover, they operate with minimum noise. Printing press gears must remain accurate, run smoothly and not develop chatter from wear. A typical Meehanite gear installation is at the Harris, Seybolt, Potter Company, and is shown in Fig. 17. These gears go through the break-in period without developing a back-lash from wear that needs to be taken up by adjustment. Gears in other materials have always given this trouble.

Shock

Where considerable shock is to be encountered, it is usual to use alloy steels of exceptional ductility. However, as shown in the first portion of this Paper, the impact strength of Meehanite is distinctly superior to what might be inferred from the conventional tensile test-bar data and the background of cast iron. This capacity of absorbing shock is further supported by its relatively high damping capacity for vibration as compared with the low value for steel and also by the fact that it is less sensitive to stress concentration from sharp changes in contour. Interpreted in terms of actual service, it has been shown that of all cast ferrous metal gears, Meehanite is in special installations able to withstand impact and shock equally as well as some of the more costly steel gears.

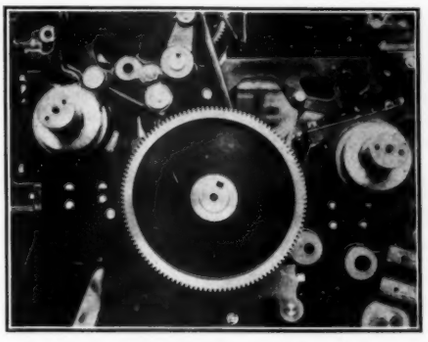


FIG. 17.—PRINTING-PRESS GEARS IN HIGH-DUTY CAST IRON.

There are numerous installation examples of which a cold header machine is typical. The drive is 30 h.p. through a steel pinion which drives a 48-in. Meehanite bull gear. This machine is automatic, and in case of difficulty the motor is plugged for instantaneous stopping. This gear transmits power for a 150-ton blow in the stroke at the rate of 100 per min.

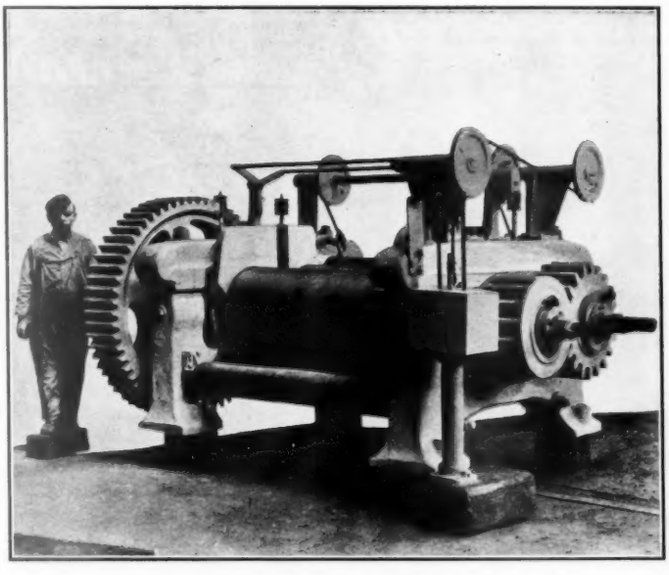


FIG. 19.—RUBBER CALENDER MILLS NOW HAVE THEIR GEARS MADE IN THE NEWER CAST-IRON ALLOYS.

The Eberling Machine Company use as-cast Meehanite in a crank type coal briquetting machine. The lever arrangement is 2 to 1 operated by a cam to apply a 140-ton pressure to the briquetting die. The gear teeth are cast on the gear and lubrication is negligible. The maximum load always comes on the same teeth of the gear and if the machine is stalled it has to be backed up by using a crowbar in the gear teeth. Over 200 of these machines are in service, all using Meehanite gears with great success. The gears are 32.66 P D — 96 teeth 3 D P — 3¼ in. face.

Heavy Duty

Fig. 18 shows a Gordon Plasticator, and because of excessive wear, the forged steel gear had to be replaced after six months of service. This gear is 72 in. diameter, 20 in. face and transmits 300 h.p. at 30 r.p.m. When made in Meehanite, it showed so little wear after the same conditions of service that it was difficult to determine which side of the teeth were wearing surfaces. In one particular installation where the horse-power is 258, the gear is running with a pinon which was cut by the customer with a milling cutter instead of a hob. Despite the fact that the teeth did not mesh properly and premature failure was anticipated, the gear has now been in service over three years and is still in good condition.

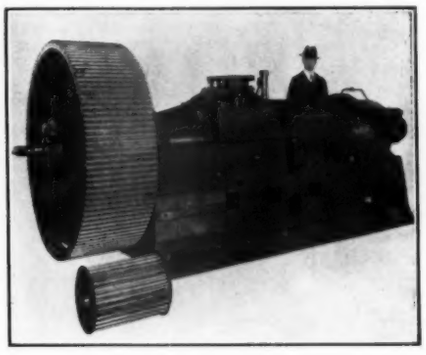


FIG. 18.—THIS GEAR—72 IN. DIA.—IS NOW MADE IN CAST IRON INSTEAD OF FORGED STEEL.

Another interesting installation is for rubber calender mills. These gears are 72 in. diameter with a 12 to 14 in. face and circular pitch 3 in. (Fig. 19). These are replacing steel gears that wear out or break in service prematurely. Meehanite after five years' service shows little or no wear.

FIG. 20.—SHOWS RELATIVE WEAR WHEN MADE FROM THREE DIFFERENT ALLOYS.

Gear Train in Crane Hoist.—To date, these gears made in A Meehanite have given more than four times the life of the steel gears used formerly.

Pinion and Roller Shaft Used for Drive for Sandblast Barrel

The G.H.R. Foundry Company of Dayton, Ohio, report: "The pinion (Fig. 20) is an

8-tooth, 8$\frac{1}{8}$ in. overall diameter, with 4-in. face. The tooth is 1$\frac{1}{2}$ in. high, 1$\frac{3}{8}$ in. thick up to pitch diameter and reduced through proper radius to 1$\frac{1}{8}$ in. at the top. Two pinions are used for the drive, four rollers carry the load, two of which run free and the other two being attached to the pinion drive shaft. The driven load on each pinion is approximately 3,500 to 4,000 lbs., varying with the movement of the casting load in the barrel, the casting load in the barrel amounting to an approximate average of one ton. To this actual load must be added the drag resulting from the wear on the rollers and the change in the pitch diameter as the teeth of the pinion wear down. In addition to the load, the pinion is exposed to a very severe abrasion due to the cleaning medium consisting of steel grit sifting through into the area in which the drive is located. The driven gear has 64 teeth, the ratio being 8 : 1.

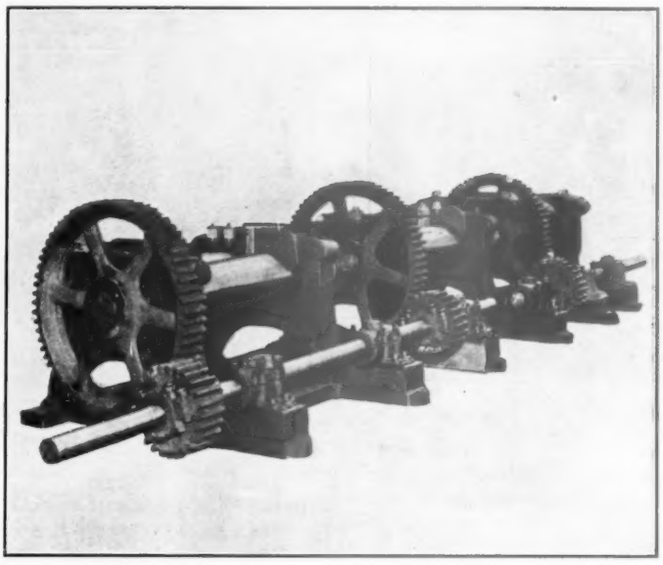


FIG. 21.—A TYPICAL GEAR INSTALLATION WHERE SPECIAL CAST IRON IS USED.

FIG. 23.

"The casting—the first one on the left in Fig. 20—is a Meehanite A that has not been used and is for comparison only. The used pinion—in the centre—is a Meehanite A and that on the right is heat-treated alloy steel and is one of the second set of such steel pinions used.

"The following is a record of the production results from the heat-treated alloy steel pinions and the heat-treated Meehanite:—

	Loads.	Tons blasted.	Average load. Tons.
Heat-treated steel ..	770	750.5	0.975
Set Meehanite heat-treated	1,099	1,084.25	0.987

"The heat-treated Meehanite pinions show wear on the teeth of about $\frac{1}{4}$ in., and we anticipate that before replacement we will get at least three times the present production.

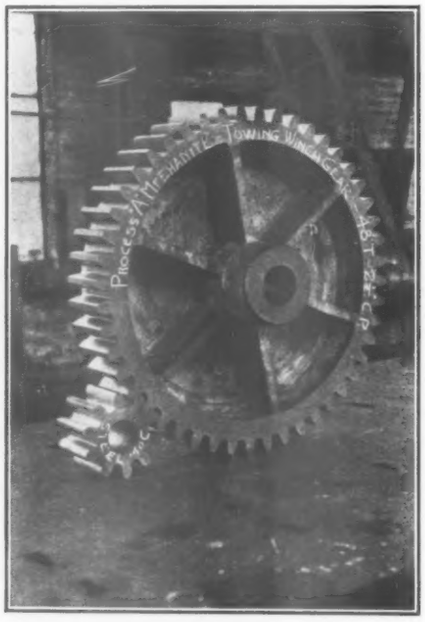


FIG. 24.

"We call particular attention to the remaining tooth section on the Meehanite pinion. While the design on the tooth to carry the drive load provided for a 1$\frac{3}{8}$-in. section yet the Meehanite pinion drove the load until there was only $\frac{1}{4}$ in. of the section left.

"This is an outstanding demonstration of the possibilities of Meehanite under the most severe and rigourous service conditions."

Figs. 21 to 24 illustrate cases where these newer alloys have given outstanding results.

Concrete Mixer Drum Ring Gears

These gears are 10 ft. dia., 20-in. overall face, and the weight of the drum and contents is 18 tons. These mixers mix four cubic yards of concrete at a time, and six of such machines mixed all of the concrete for the Boulder Dam and at the end of the service the gears showed no wear.

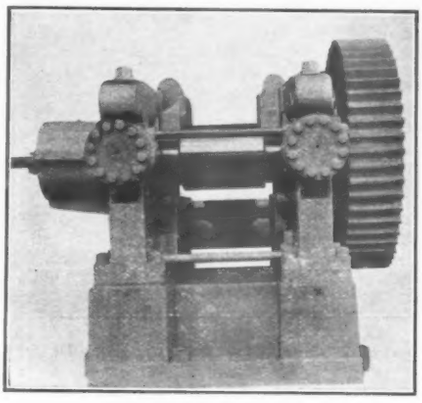


FIG. 22.

Ring Gears for Cement Mill

Fig. 25 shows an installation calling for high wear resistance. The gears were made in "B" Meehanite and chilled. Fig. 26 shows a fracture through the tooth, displaying the penetration of the surface hardness of the teeth attached to a tough and machinable core and ring. The outer case of the teeth has a Brinell hardness of 477, and the core 207. The blending of the case and core is an important feature of this process. The case, whilst not glass hard, combines exceptional wear resistance with toughness and strength. The gear after twenty-six months continuous service shows no sign of wear, excepting high spots which have taken a mirror like polish.

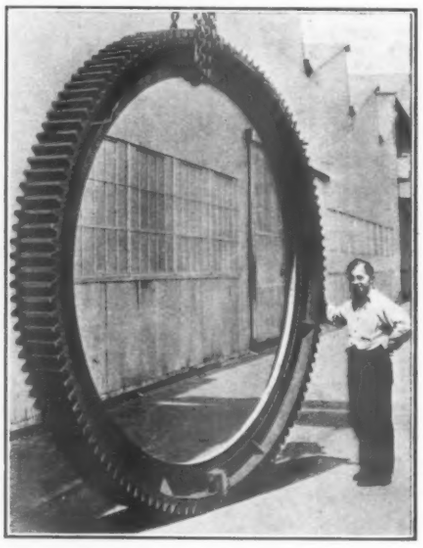


FIG. 25.—IN THIS GEAR A CHILLED STRUCTURE IS CALLED FOR.

One advantage of hardening teeth this way is, of course, that it avoids heat-treatment. Meehanite gears, however, may be heat-treated much in the same way as steel, and Fig. 27 shows the

FIG. 26.—FRACTURE THROUGH A GEAR TOOTH, SHOWING PENETRATION OF HARDNESS.

physical properties of A meehanite after tempering at various temperatures following oil quenching. To surface-harden a sand-cast Mee-

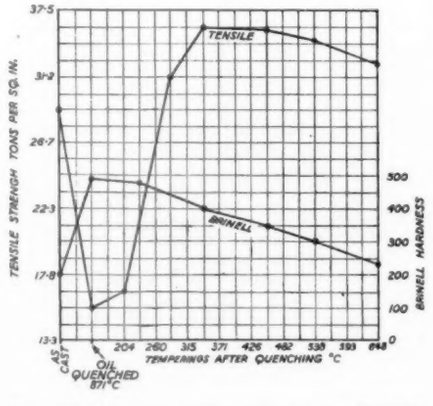


FIG. 27.—PHYSICAL PROPERTIES OF A SPECIAL HIGH-DUTY CAST IRON AFTER TEMPERING.

hanite gear, the well-known torch hardening method is successful and is recommended in those installations where the advantages of surface hardening are desired.

Air-Conditioning in Electrode Factory

An air-conditioning unit has recently been installed in an American plant, it having been found that the quality of flux on electrodes for welding stainless steel is improved and the rate of production increased when the plant atmosphere is maintained within definite temperature and humidity conditions. The unit includes an air conditioner, ammonia compressor and temperature and humidity controls.—" Steel."

The National Defence Contribution

BY F. J. TEBBUTT.

The National Defence Contribution is a tax additional to Income Tax and is based on the same principles, although there are differences as regards both deductions and treatment of certain income items. The tax will also apply to a fewer persons, as professions, offices, and certain employments are outside the tax, the tax applying to trades and businesses coming within Case I of Schedule D (business profits; own account); companies will pay 5 per cent, firms and individuals 4 per cent. This new tax, however, will only be imposed where profits are in excess of £2,000 per annum; furthermore, for businesses with profits of less than £12,000 per annum, the full profits will not attract the tax, there being an abatement allowed of one fifth of the difference between the assessed profits and £12,000. Take profits at £3,000, the difference from £12,000 is £9,000; one fifth of this sum is £1,800 which taken from £3,000 leaves £1,200 to attract the tax. Companies on the 5 per cent. rate will thus pay £60, other concerns £48, instead of £150 and £120 respectively if tax were paid on the full profits of £3,000.

Assessment Procedure

Provision is only made for the tax to run for five years, that is it will apply to profits made in the period between April 1, 1937, and March 31, 1942. Assessment will be made separately to those for Income Tax, but will similarly be for 12 months period, called a " chargeable accounting period "; the year-ending date will be according to the year ending date of the particular firm's financial year that falls within the five years as above. If the incidence of that date is such that an accounting period will be shorter than 12 months, tax will be payable for that shorter period; for example, if a firm's year-ending date is December 31, the first period would be for nine months, April 1 to December 31, 1937; at the end of the five years, the period would be for three months, January 1, 1942, to March 31, 1942. The abatement rule as above in these shorter periods would work with the necessary proportion of the figures of £2,000 and £12,000 relevant to the shorter basis period.

Contrasts with Income Tax Procedure

As with income tax, an allowance will be made for wear and tear (machinery and plant; the term includes motor vehicles and fittings and fixtures) and for losses; furthermore the " carry forward " rules which allow unused amounts to be carried forward—wear and tear indefinitely, losses mostly for six years—will also apply somewhat similarly to the new tax. There is, however, a departure from income tax procedure as regards payments for interest, annuities, and other annual payments and for royalties, for, whereas these items under income tax law cannot be deducted, the new tax provisions allow such payments to be deducted. It is useful to note, however, that the term " interest " means interest paid on loans; the provision includes debenture interest in the case of companies, but it does not apply to payments of dividends or distribution of profits. Moreover, a deduction cannot be made for any of the foregoing items if paid to any person carrying on the business; if a director-controlled company, the directors will be deemed to be carrying on the business for the purposes of this rule.

If the company is one with the directors having a controlling interest therein, really meaning where the other shareholders are few and with no power to determine policy, there is a safeguarding provision to prevent all profits being distributed as directors' remuneration leaving no profits to attract the tax. The scheme provides that in the case of these companies a deduction for directors' remuneration cannot exceed 15 per cent. of the profits (before remuneration is deducted) or £1,500, whichever is the greater, but in no case can the total deduction exceed £15,000; for an accounting period of less than a year the relevant proportion of £1,500 or £15,000 will apply. This limiting of directors' remuneration rule will not apply to what are termed in the Act " whole time service directors," these being persons who are really full time servants in a managerial or technical capacity, but who hold a few shares to qualify for the board, but if the holding is more than 5 per cent. of the ordinary share capital of the company the remuneration rule will apply for the tax.

An ordinary partnership concern (not a company) can, if it desires, elect to be assessed as a director-controlled company and be allowed deductions for directors' remuneration, as if the partners were directors, the deduction being restricted as above; in such a case, however, the tax would be 5 per cent. and not 4 per cent. as would otherwise apply.

Investment income is taken into consideration for income tax, but it will not be charged under the new tax, and this provision will apply to all concerns, companies, firms and individuals alike, except as regards certain special trades, such as assurance societies and banks.

Payments made for U.K. income tax are not allowable deductions for the new tax, but payments for Dominion income tax can be so deducted. A useful point to note is that the payments made for the National Defence Contribution scheme can be deducted as a trading expense for income tax purposes.

An assessment can be made any time within six years from the end of the relevant accounting period, and is due and payable at the expiration of one month from the date of assessment. " Annual value," which is an allowable deduction under income tax law (Schedule A assessment; owner occupied premises) cannot be deducted for the purposes of the new tax.

Professions where the profits are derived wholly or mainly from the personal qualifications of the individual (or by individuals in partnership) carrying on the profession, are outside the scope of the new tax. Any business which consists wholly or mainly in the making of contracts for other persons, or giving advice on the same matters, is included for the tax, and is outside the definition of the term " profession."

American Sand Testing Technique

(*Concluded from page* 80.)

that he may compare them with foundry conditions. One copy is to remain in the sand laboratory for record, and suitable space should be provided on the form for remarks.

(4) The strength of the moulding sand should be controlled by uniform daily additions sufficient to maintain the bond to the point of good production. Irregular additions of new sand or bond are the cause of much foundry trouble.

(5) The fineness of the sand of the various heaps may be made by comparing the grain distribution. Changes in sand, such as increasing or decreasing of fine or coarse sands, can be noted, and the remedy applied before serious conditions arise.

(6) Sand control depends upon good testing technique, good equipment, standard methods, and intelligent interpretation of all available facts, both in the making and use of the sand.

THE NEW IRON-ORE FIELD near Divrigi in Turkey, which has been exhaustively explored during the last year, is reported to contain 60 to 65 per cent. of iron and to total 10,000,000 tons of ore. No deep borings have yet been put down, but are contemplated in the expectation that further favourable data will be obtained.

Costs in a Grey Iron Foundry

At the Thirty-fourth Annual Conference of the Institute of British Foundrymen, held in Derby from June 8 to 11, the Costing Sub-Committee presented a report on "The Establishment of Costs in a Grey Iron Foundry." This was published in our issues of June 10 and 17, and the interesting discussion which followed is printed below.

MR. A. SUTCLIFFE suggested that to a practical foundryman the Paper was worthless. He was prepared to go with the Costing Sub-Committee to try to apply its recommendations to a jobbing shop, and he was not optimistic about the results. No two men worked alike in a jobbing foundry. One would use more sprigs or more facing sand than another; one would make more wasters than another. Only the moulders on the floor could produce the castings, and that fact rendered costing difficult. There were also difficulties with regard to patterns, some of which seemed to be constructed rather for appearance than for use. How were they to be costed? Sometimes they were designed by the drawing office and made by a joiner; they had to be twisted in various places, and a great deal of time had to be spent in putting them right. He had nothing against this Paper, but, being a craftsman, he felt that the Sub-Committee was catering more for the repetition and mechanised foundry than for the jobbing shop.

THE PRESIDENT, MR. C. W. BIGG (a member of the Sub-Committee) accepted Mr. Delport's invitation to reply to Mr. Sutcliffe. He said that if any of the moulders used more sprigs than they should use, he would very quickly find out the reason. The management should be capable of deciding the correct number of sprigs to use for a job, and it should not be left to the discretion of the individual men on the floor. As to the other questions raised by Mr. Sutcliffe, he said that to every other man in the room they answered themselves.

MR. J. H. COOPER emphasised that the purpose of the Paper was to help founders to deal with their problems from their different angles and to secure the best possible results. It seemed, he said, that Mr. Sutcliffe was regarding the Paper in the wrong light, overlooking the fact that founding was team work and was not individualistic.

A Simplified Scheme Needed

MR. C. E. WILLIAMS (Past-President), in a tribute to the Costing Sub-Committee, commented jocularly that perhaps he was to blame for having given them the task of getting their figures and recommendations together, for during his year of office as President he had suggested that it would be a good thing to impress upon the small jobbing founders particularly that there were other factors in their costs besides pig-iron and coke. Sometimes it seemed to him that a founder added together only the costs of his pig-iron, coke and labour, adding 10 per cent. for profit; the Paper contained suggestions which would enable the small founder to arrive at cost figures which were nearer the truth than would be the case if he shut his eyes to the fact that there were such things as sand, springs, blacking, etc. The work of the members of the Sub-Committee had involved them in considerable travelling and expense, and the members had devoted a great deal of their time to the work, which was very heartily appreciated; but it would be a good thing if they could throw out a somewhat simpler scheme, suitable for application to a jobbing foundry.

Costs, Overheads and Piece-work

MR. J. ROXBURGH said it was perhaps safe to assume that most foundries, whether large or small, had some system of costing in operation. Probably in the beginning the costing systems used in some cases were devised and introduced by persons who were not altogether familiar with or appreciative of the diversity of products and processes used in the foundry. It was, therefore, a matter for congratulation that the Costing Sub-Committee, composed of foundrymen, had gone to the trouble of investigating costs from inside the industry. He believed that, generally speaking, the principles enunciated and the recommendations made in the Paper could form a basis upon which a proper costing system could be devised Therefore, he felt that the industry should accept the recommendations generally. The Sub-Committee had pursued the correct course in applying the overheads to the direct costs, but perhaps a point such as that was worthy of still further attention. It was well known that in any scheme of payment by results the prices set should be such that an average man could earn time-and-a-quarter. For instance, in the case of a piece-work job where 500 hours was allowed, and where the job was actually done in 400 hours, the moulders earned a bonus of 100 hours. He contended that the overhead figure should apply to the actual number of hours worked, *i.e.*, the 400 hours, and that the cost of the extra 100 hours was merely added on. If the cost of the 100 hours was £7, that amount should be spread over the whole cost of the casting.

The Sub-Committee were also to be congratulated on the fact that, in regard to metal and melting costs, they had gone a great deal further than they had in their preliminary report, and the bogie of the price of domestic scrap had been brought nearer solution in the present report than in the previous one. If, as they had suggested, the scrap resulting from each type of metal mixture were weighed and booked out to its respective pile in the yard, and any scrap used from this pile booked back again to the foundry, a correct record of each type of scrap material would be obtained. The finished castings resulting from each type of metal mixture would also be recorded and, from this information, the cost of metal would resolve itself into purchases of metal and scrap against each mixture, divided by the weight of finished castings obtained from each mixture.

This report was of immense importance to the industry, and an executive of a foundry should not only know his costs, but should be able to interpret them so that they would serve as a reliable guide to help him to improve the efficiency of his department. It was particularly significant that the President, in his address that morning, had laid particular emphasis on the subject of costing in the foundry.

Establishment of Fundamentals

The PRESIDENT said that, as a practical man, he had endeavoured to found all his later reasoning on the principles he had acquired at the bench in his early days. Messrs. Qualcast, Limited, had been moderately successful, and a tremendous amount of the success it had achieved was attributable to the realisation of the importance of applying proper costing principles. Costing had a value as a dimensional factor in the works as distinct from the office; that was one of its main values to the works executive, and he regarded the cost book as the barometer for the works.

From the statements made, he said, it might be thought that it was well nigh impossible to arrive at a costing system for a jobbing shop; but, in fact, that was not so. The Sub-Committee was out to establish principles. No matter how small a shop or how varied its work, an intelligent trial could be made of costing, and he was sure that even Mr. Sutcliffe would be keen about it if he would give it an unbiassed trial.

In a tribute to the Costing Sub-Committee, the President said that the members had had to devote a certain amount of time to the work, but they had all enjoyed it. He proposed a hearty vote of thanks particularly, however, to Mr. Delport, the convener, who had had to devote a tremendous amount of time to the formulation of the results of the Sub-Committee's discussion.

MR. C. C. BOOTH, as a member of the Sub-Committee and, therefore, as one who appreciated the enormous amount of work Mr. Delport had done, seconded the vote of thanks. The members of the Sub-Committee, he said, had discussed many problems which they had met in their own works, and great credit was due to Mr. Delport for the able manner in which he had interpreted their statements and had committed them to paper.

The vote of thanks was carried with acclamation.

MR. DELPORT, responding, said that the real fundamental matter contained in the report had resulted from the discussions of the views and experiences of the whole of the members of the Sub-Committee, so that any expression of thanks to him should be allocated to the Sub-Committee as a whole.

Costing, he continued, was really a question of good management, and there could not be good management in a foundry without a costing system. He hoped that members of the Institute would study the Report and would contribute constructive criticisms and suggestions; those criticisms and suggestions would be considered and the results of the Sub-Committee's investigation of them would be embodied in a final report.

A Means of Simplification

MR. S. H. RUSSELL (Past-President and hon. treasurer of the Institute) wrote that he fully endorsed all the recommendations regarding the necessity of costs. The only criticism was that it appeared to be drawn up purely from the point of view of foundries making large quantities from the same pattern, and that the average jobbing founder would be rather frightened by the amount of data he was required to collect. The essential items in costing were:—(1) Cost of metal at the spout; (2) skilled-labour cost of producing the casting (*i.e.*, moulder and coremaker); and (3) the cost of non-productive labour, *i.e.*, foremen, fettlers, labourers and works staff. This could be expressed as a percentage of the skilled labour cost, and whilst it was admittedly somewhat approximate, usually averaged out very closely, the intricate and cored work naturally absorbing a bigger share of those non-productive costs.

An accountant would quickly and easily advise a foundry as to the percentage necessary to add to the total of these items to cover overheads and a reasonable profit. He had previously expressed the opinion that cost of metal calculation could be simplified by omitting all reference to home scrap (this being made originally from the bought materials). The cost of a charge of pig-iron and bought scrap was readily obtained, and to this cost should be added the cost of fuel and materials per ton of good castings produced, obtained by averaging costs and tonnage of purchases and sales over a year. The furnacemen's wages might be either allowed for or included in the total percentage of non-productive labour. This method, admittedly, was not so accurate, but if reasonable care was taken in establishing the basic figures, the cost on any individual casting, even if only a one-off job, could be very quickly determined. It was most important that a simple system of costing, reasonably accurate, should be introduced into every foundry, and it was then inevitable that ultimately the costing would be made individually more accurate by the more elaborate system outlined in the report of the Sub-Committee.

Foundry and Laboratory Characteristics of Cupola Cokes

By HUGH O'NEILL, D.Sc., M.Met., and J. G. PEARCE, M.Sc., M.I.E.E.

(*Concluded from page 72.*)

The External Size[4]

The external size and shape of the specimen also merit consideration, for if large pieces have survived quenching at the oven and transport therefrom, the shatter resistance is likely to be good. In this respect it has been found that small pieces resulting from the shatter testing of large pieces have the same prismatic index as the latter.[5] Specimen I (index 86) (Fig. 6) is badly fissured but its shape is more promising than that of specimen J (index 73) (Fig. 7), and it is almost devoid of transverse fissuring. A quantitative system might aim at awarding marks to each coke for the various macrostructural features suggested above as contributing to shatter resistance, or alternatively a set of standard macrographs could be employed. If the average size of the coke is small it will tend to reduce the cupola temperature.

Microstructure and Cell Hardness

Cokes with a high degree of combustibility are said[4] to have a high resistance to abrasion and a pronounced cell structure displaying continuity in the distribution of the cells and a large proportion of minute pores in the cell walls. Beilby[6] has similarly outlined the microstructural features favouring reactivity as (1) large area of reactive surface, (2) minute cells with thin cell walls and (3) accessibility of reacting gases to the interior of the coke. The authors have attempted to determine the cell size distribution and cell space ratio of the present samples.

Photomicrographs of Rose's sections × 6 (Figs. 5, 6 and 7) were traversed over an actual coke length of 1.66 cm. and the intercepts of black cell wall and white cell space determined. Fissures or black patches of mineral matter were avoided as much as possible in these measurements. The readings of two traverses were averaged, and the frequency-cell size curves obtained are shown in Fig. 9. The cokes have thus been divided into three groups according to cell size distribution, and whilst the division was readily made for most specimens, cokes H, P and M proved to be rather special cases. The results are summarised in Table XVI.

A method is now being tried for the rapid determination of cell space ratio similar to that used by Barkas[8] for wood. A photoelectric cell is fitted in place of the eyepiece of the Vickers projection microscope and the Rose's macro-section is placed on the specimen stage. In this way the ratio between black and white on the object can be determined.

A few experiments have also been made regarding the mechanical properties of the coke material when free from major fissures. It was felt that the static compressive strength and the abradability of *small* test-pieces were more likely to be associated with constitution and combustibility than mechanical tests on large specimens. Cubical pieces fractured in compression after their top and bottom surfaces had been bedded in the test machine with *ciment fondu* gave the results recorded in Table XV.

Grinding tests were made in an 11⅝-in. by 4¾-in. dia. steel cylinder containing three ⅝ in. dia. steel rods and rotated for a standard time of 2 hrs. at 30 r.p.m. The initial coke charge of 100 grms. was screened to be between B.S. sieves 8 and 16, i.e., 0.081 in. and 0.0395 in. apertures, and the material was afterwards given sieving analysis up to B.S.S. 300. The increase of surface area or grindability index (C) was determined by Cross's method,[7] and for purposes of comparison the reciprocal of this may be considered as the resistance to abrasion.

Prof. Riley (Northern Coke Research Committee) has kindly carried out micro-impact tests on the cokes by a method which he will shortly publish. Two grams of properly sampled material graded between B.S. sieves 14 and 25 are impacted with steel balls for 800 revs. in a tube rotating about its transverse axis. The breakage is determined by sieving analysis and the "micro-impact index" or resistance to abrasion is expressed as the percentage of original material remaining on B.S. sieves 25 and 72. The authors have taken the liberty of referring to the percentage on 72 B.S.S. alone as a simplified abrasion index. Results are given in Table XV, and it will be observed that the L.M.S. and N.C.R.C. abrasion tests agree quite well.

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Discussion of the Results

Table XVI has been drawn up largely on the basis of microstructural observations for comparison purposes. In an endeavour to obtain a hint as to where generalisations might be made, Table XVII has been prepared by arbitrarily selecting a division in the values of certain suitable tests below which the result is called "low" and above which it is "high."

It can be said fairly definitely that the three cold cupola cokes B, K and J gave low results for the five tests reported in Table XVII, and the converse tendency is noticeable for the hot cokes.

The negative and very low (RI—RIII) reactivity values for the dense uniform cokes, C, B, K and J are interesting, and indicate that the fuel becomes more reactive as it burns away. This suggests a relative increase of the surface area of the cell walls as combustion proceeds, possibly by pitting, in the manner suggested by Burrage,[8] during the activation of charcoal. The degree to which such pitting or surface enlargement occurs might well be affected by the micro-constitution of the bituminous conglomerate which was the source of the coke. A negative (RI—RIII) value is said to be abnormal and has previously been associated with beehive cokes by the Fuel Research Board.[9] From the same source has come the suggestion that low reactivity cokes are metallurgically desirable, and that low RIII values correspond with high shatter results. The present work within its own narrow limits does not confirm this suggestion. Mott[13] has reported that low reactivity gives high coke bed temperatures, but considers that the fuel size may be of greater importance than reactivity. A probable difficulty regarding the reactivity test is the selection of an arbitrary combustion temperature of 950 deg. C., for whilst it probably places cokes in the correct order of reactivity at this temperature, the order might be different at 1,300 deg. C.*. In this respect Riley[10] states that whilst below 1,000 deg. C. "amorphous" carbon is more re-

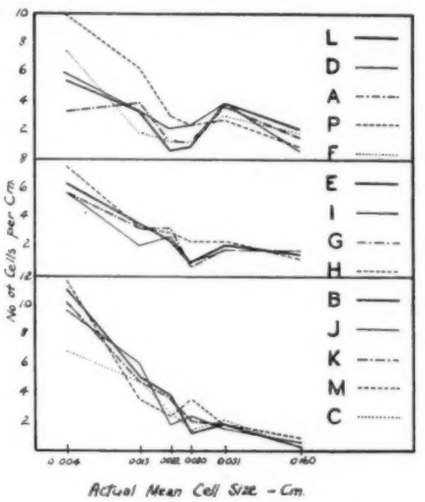

FIG. 9.—GROUPING COKES BY CELL SIZE.

TABLE XVII.—*H = high, L = low.*

Coke reference.	Cupola temp. H ⩽ 1,305 deg. C.	Shatter index (2 ins.). H ⩽ 80.	Wet oxidation test. H ⩽ 187.	Openness of microstructure (per cent. black cell wall). H ⩾ 60.	N.C.R.C. resistance to abrasion. H ⩽ 60.	Reactivity test (RI–RIII). H ⩽ 30.
L	H	H	H	H	H	H
F	,,	,,	,,	,,	,,	,,
A	,,	,,	,,	,,	,,	,,
G	,,	,,	,,	,,	,,	,,
I	,,	,,	,,	,,	,,	,,
H	M†	,,	,,	,,	,,	L
E	L	,,	,,	,,	,,	H
P	H	,,	L	,,	L	,,
C	,,	,,	,,	L	H	L
M	L	,,	,,	H	L	H
D*	,,	L	,,	,,	H	,,
B	,,	,,	,,	L	L	L
K	,,	,,	,,	,,	,,	,,
J	,,	,,	,,	,,	,,	,,

* Beehive coke.

† M = medium (see Table VIII).

* For the Tables and Figs. mentioned in this section and which do not appear, consult FOUNDRY TRADE JOURNAL, July 15, pp. 46 to 50, and July 22, pp. 66 to 72.

active to oxygen than graphite, above 1,000 deg. C. the reverse is probably true.

As regards the combustibility test, the only observed point of interest was that the rate of combustion (and the $CO:CO_2$ ratio) appeared greatest with cokes P, C, M, J1, K and B, and these are fuels with the greatest number of cells per cm. (Table XVI). Support is not provided for the view[14] that a high rate of combustion corresponds with a low shatter index and a low apparent porosity test result (Table XV).

By considering the cokes on a basis of their native coalfields, certain tendencies have been isolated which are indicated in Table XVIII.

In a given group the cupola temperature decreased with decrease of wet oxidation, reactivity, combustibility, $CO:CO_2$ ratio, and shatter result. The carbon pick-up of the Durham cokes increased with their wet oxidation test results.

TABLE XVIII.—*Test Results arranged According to Coalfields.*

Coalfield.	Coke ref.	Cupola metal temp. Deg. C.	Wet oxidation test.	Reactivity test. RIII.	Reactivity test. RI–RIII.	Combustibility test. $CO:CO_2$ ratio.	Shatter index. 2-in. screen.
Durham ..	316	†	218	70	37	0·71	87
	317	†	178	61	71	0·70	91
	L1	1,340	204	59	45	0.71	85
	G1	1,320	201	47.5	43	0.65	84
	A	1,310	194	55	34	0.66	85
	I	1,305	189	42	32	0.69	86
	H	1,300	208	46	17.5	0.60	88
Lancs ..	P	1,315	141	124	+66.5	1.01	93
	B	1,300	133	118	−17.5	0.76	73
S. Yorks ..	C	1,305	161	157	−12.5	0.84	86
	D*	1,290	150	55	+33.5*	0.58	73
S. Wales ..	F	1,310	217	43	35	0.55	89
	E	1,295	230	39	30	0.59	84
Scotch ..	K	1,290	167	54	4.5	0.83	71
	J1	1,270†	144	27	−12.5	0.68	73

* Beehive coke, reactivity generally abnormal. † Results not representative.

The fact remains that in spite of all the laboratory tests the safest method of judging an unknown coke of the present series is by means of a controlled practical trial. This view is supported by the results of the work of the Midland, Northern and Scottish Coke Research Committees, operating in conjunction with the Iron and Steel Industrial Research Council. Since this Report was prepared, a Paper summarising the work of these Committees has been presented to the Iron and Steel Institute by Evans and Ridgion.[11] The authors state ". . . it is frequently a matter of considerable difficulty to express quantitatively the difference between cokes by methods of testing at present available." They add that "the shatter test has proved a useful tool, but is not in itself completely satisfactory as a measure of the strength of the coke," and that "if anything, the information available suggests that cokes of high specific reactivity to gases are not desirable for cupola or blast furnace practice," and finally "Whilst laboratory tests have their value, the ultimate effective method of testing coke is in actual service." The same view is confirmed by recent German work.[13]

Quite apart from the conclusions to be drawn, it is thought that the data presented for a wide variety of tests will be useful in showing values obtained from a group of cokes from the principal coalfields for the period 1934-36, and the variations to be expected.

Summary

(1) Cupola results of the behaviour of fourteen different foundry cokes are given. A very complete laboratory examination of the cokes is also reported, special attention having been devoted to macrostructure and microstructure.

(2) Coke merit for a cupola charge ratio of 16:1 has been assessed on a basis of metal temperature. Certain cokes were proved to be as good as more famous brands of higher price.

(3) Determinations of the sulphur and carbon pick-ups from eight of the cokes were made in a small experimental cupola. Broadly speaking, the sulphur pick-up of the metal was directly proportional to the total, and to the combustible sulphur contents of the fuels. The carbon pick-up tended to increase with (*a*) the cell-structure openness; (*b*) the combustibility test rate, and (*c*) the fixed carbon content. Incidentally the fixed sulphur decreased as the wet oxidation test value increased.

(4) Cupola metal temperatures were determined to within about ±0.5 per cent., but the results for the best and worst cokes only differed by about 5 per cent. The field for correlating cupola and laboratory tests therefore proved unfortunately to be very narrow. Under these circumstances none of the tests can yet be relied upon to predict the practical cupola properties of a coke of unknown origin, but the most helpful in this respect was the shatter test.

(5) Correlations between the various tests themselves and the cupola results hint at the following generalisations for these particular samples:—

Cokes giving *low* metal temperatures are *low* in:

(*a*) Shatter index.
(*b*) Rate of wet oxidation.
(*c*) (RI − RIII) reactivity value.
(*d*) Resistance to abrasion.

and *high* in:

(*a*) Density of cell structure.
(*b*) Resistance to static compression.

(6) If these few cokes are considered in groups of their native coalfields, the following generalisations suggest themselves:—

A *decrease* of cupola metal temperature is associated with a *decrease* in:

(*a*) Shatter index.
(*b*) Rate of wet oxidation.
(*c*) (RI − RIII) reactivity value.
(*d*) $CO:CO_2$ ratio in the combustibility test.

Acknowledgments

Acknowledgment is gratefully made to Prof. H. L. Riley and the Northern Coke Research Committee, to the Fuel Research Board, and to the Chemical Section of the L.M.S. Research Department for kindly undertaking some of the laboratory tests. The rest of the work has been carried out by Mr. L. W. Bolton, Mr. C. Rowley and Mr. P. H. Shotton, of the British Cast Iron Research Association; and Mr. R. Insley, G.I.Mech.E., and Mr. J. Bradley, B.Sc., of the L.M.S. Research Department. Thanks are due to Mr. W. A. Stanier, M.I.Mech.E., chief mechanical engineer of the L.M.S., and his staff, for co-operation; to Mr. T. M. Herbert, M.A., research manager of the L.M.S., for his interest, and to the Council of the British Cast Iron Research Association and Sir Harold Hartley, C.B.E., F.R.S. (Vice-President and Director of Research of the L.M.S.) for permission to publish the results.

DISCUSSION

The CHAIRMAN (Mr. F. J. Cook) said that this was a Paper the industry had been seeking for many years and one which perhaps had not carried the subject as far as one would have wished, but Mr. Millington, the originator of the research, was present, and he invited him to speak.

Wet Oxidation and Reactivity Factors

MR. E. MILLINGTON said that, as Mr. Cook had referred to his having been responsible for this research in the first place, and although now retired from active service, it was with pleasure that he would make a few observations. He congratulated Dr. O'Neill and Mr. Pearce on the excellence of their report, which he characterised as a complete subject presented in masterly fashion. The origin of the report was based on previous work carried out by the L.M. & S. Railway Company, in which valuable, but inconclusive, results had been obtained. Since it was his duty to advise the buying department on the quality desired, this had to be based largely on the experience of the various foundries, with uneconomical results.

In view of his own work and that of others, such as the Fuel Research Stations, the Northern Coke Committee, it was felt that a comprehensive research would be justified having for its object the formulation of a specification for the purchase of foundry coke having the desired properties. This proposal was discussed with Mr. Pearce, who welcomed the scheme with enthusiasm. All the known available tests as given in the Paper were brought in so as to cover the ground as far as possible. As to the results obtained, it was clearly shown that, apart from the physical side, such as the shatter, macro- and microscopic tests, little was to be gained from what might be described as the purely chemical side. But this was not known, and the research was justified in that it had at least cleared the ground for the time being. This did not dismiss from further study the ultimate service of the now rejected tests; on the other hand, it might intensify a closer study of these methods, such as wet oxidation, reactivity, etc. On reflection, it was perhaps not surprising that the chemical tests, and in a measure the physical ones also, had failed in their object. For, after all, it was the properties and the behaviour of the coke while in an incandescent state supporting a heavy burden, that one desired to know, and what might be satisfactory in the relative cold might be altogether different in the hot state. It was now possible to divide cokes into groups identifying their district origin, and by grouping the methods of testing to formulate a restricted specification. Up to the present, however, the ultimate tests rested with the cupola.

Finally, he would like to congratulate the members of his old staff for the excellence of their work, and to extend these to his friends of the British Cast Iron Research Association.

Routine Acceptance Tests

MR. PEARCE said he would like to say with what pleasure he looked back on his early contact with Mr. Millington on this research. The Paper proved that coke was just as complicated as pig-iron and cast iron. The Paper raised the question of the position of chemical tests, because he thought that analyses were the most common tests applied to coke. It could be stated

that their value was that, when one bought coke, one wished to buy carbon, and if these tests were made, it could be stated how much of the outlay was being expended on that constituent. Also, chemical tests were very good checks on regularity from delivery to delivery. How far were these results applicable to the purchase of foundry coke? The answer was that in a limited degree, they were applicable. If one was compelled for transport reasons to buy coke wholly from one coalfield, these tests could definitely be used to sort out one coke from another. These results, of course, would not apply to blended cokes, and the future might provide further light on correlating the different fields. In a general way, the tests as a whole showed up the good cokes as the best, although an isolated bad result of one test on a coke would not justify its condemnation.

Melting Practice as Controlling Factor

MR. BEN HIRD said this subject was important, and no doubt all foundrymen would agree that bad coke would spoil the best of iron. Thus coke was a fundamental factor in producing good iron. It might be possible to use inferior coke for railway chairs, but the economy was very limited. To obtain good results, the best coke was necessary, especially if the castings were to be machined and subjected to pressure tests, and it would certainly prove to be the most economical.

He agreed with Mr. Millington that the future research in this subject would be in the direction of a close study of the reactions in the cupola during melting. One line of investigation suggested was the effect of the ash content. Was there a possibility that a high percentage of ash formed a slag when the coke burnt and covered the carbon particles, thus preventing proper combustion?

The most reliable test available was the shatter test. If a coke would not carry the burden of iron, and withstand the abrasion of the descending charges, it became disintegrated, and created bad melting conditions; this was especially important when mechanical charging of the cupola was used.

Cheap Coke May Give Satisfaction

MR. PEARCE said there was much to be said for the point that the best coke was the cheapest, but the L.M.S. foundries were now using cokes, the recommendations of which were based on this work, and, so far as he could say, no complaint had been recorded. The present situation with regard to coke must be considered, because foundries may be forced to use coke of a different or inferior brand from that to which they were accustomed. The situation was not as bad as during the coal strike, but all metallurgical assistance should be made use of in burning coke of a different kind from that obtainable under normal conditions. He did not think, with regard to the ash content, that the coating of slag on the coke would seriously interfere with combustion. It had been found in the blast furnaces that increase in the ash content of the coke had a much bigger effect than would be expected from the mere increase in the ash. The shatter test, too, had to be taken with some little reserve. On cupola coke it turned out to be the best available test, but the shatter test was not accepted by all experts as absolutely reliable on all cokes. The Committee which concerned itself with the Durham fields thought it very good, but the Committee concerned with the Midland fields was not so satisfied, and for that reason attention was being called to the Cochrane or drum test.

Influence of Coke Size

MR. J. ROXBURGH said that, as a foundry manager engaged on high-class engineering castings, it appeared to him that a great deal of the success of cupola coke, apart from the coke itself, depended on the efficiency of the cupola practice. Obviously, there must be a certain bed of coke, a certain separating charge, a definite volume of air, blast pressure and so forth, and he had definitely proved and always maintained in personal practice that the use of a good quality coke was essential. It was also necessary to have white hot metal, apart from the cost. There was no mention in the Paper with regard to the size of coke, and he felt that whether the coke was large or small or whether it was uniform in size, either uniformly large or small, had something to do with the successful use of coke. The authors of this Paper were to be congratulated on the work they had carried out, and if, as a result of the research, it had been proved that certain tests were of no commercial value, he still felt the work had been worth while, and if in the future, due to further research, tests were made which could be applied usefully in a foundry, he thought foundry managers would be only too pleased to have the knowledge of those tests.

Influence of Cupola Design

MR. J. H. COOPER said he had personally given this subject great consideration and for many years he had carried out much research work on it. The point which had given him much concern in this Paper was the shape of the cupola in which the test has been carried out. In practice he found that to have a cupola to work well it was necessary to have at least a height equal to the diameter running straight above tuyeres. He found that gave the best conditions. He could not see how it followed that there was a difference in the analyses of the slag from 25 to about 6 per cent. FeO. There must be some reason for this variation. The sole idea, he thought, was to try and keep the tuyeres from becoming blocked. He did not think he had ever seen a cupola made in the form outlined in the Paper. Perhaps it was made for the test. Would the authors recommend in actual practice a cupola made to a design of this description?

TABLE A.—*Tabulated Results of Three Durham Blast-Furnace Cokes.*

Size ..	Coke A.			Coke B.			Coke C.		
	Over 1½ in. 94.5 per cent.	1½ to ½ in. 2.5 per cent.	Under ½ in. 3.0 per cent.	Over 1½ in. 95.5 per cent.	1½ to ½ in. 2.9 per cent.	Under ½ in. 1.6 per cent.	Over 1½ in. 95.6 per cent.	1½ to ½ in. 2.2 per cent.	Under ¼ in. 1.8 per cent.
Ash. Dried ..	12.30	13.40	31.60	10.00	11.70	19.80	10.40	13.00	23.30
Sulphur ,, ..	0.85	0.96	1.02	1.30	1.51	1.57	0.85	0.96	0.91
Volatile ,, ..	1.15	1.50	5.50	2.30	2.30	4.00	0.95	2.50	3.00
F.C ,, ..	85.70	84.14	61.88	86.40	84.49	74.63	87.80	83.54	72.79
Moisture ..	6.50	10.50	12.50	2.00	7.10	10.20	4.90	8.95	23.00

The coke ratio was not much better than one had in Scotland. Some cokes were distilled to destruction, so there was not the same calorific value. Many foundrymen had adopted cupolas to work with square tuyeres which had given excellent results. He thought when using a cupola the chief points were to burn the coke to CO_2, reduce oxidation to a minimum and try to keep the tuyeres clean.

MR. F. J. COOK said the primary object of the research was to see if the L.M.S. Railway could find a coke cheaper than the very high priced one they had previously used, and to see if they got value for money from the dearer material. This work afforded a very good opportunity to carry out a full research on the cokes being tried with a view to extending the knowledge of coke and its behaviour under standard working conditions.

Routine Testing

MR. P. A. RUSSELL said he had been extremely interested to see the results of this research, and he was particularly interested in the conclusion that there was nothing like a practical trial. Fortunately, it was not difficult for the average foundry to conduct this.

He endorsed the views expressed in the discussion that cupola control was more important than coke control, and his experience was that many complaints originally attributed to coke ultimately proved to be due to faulty cupola operation. There were instances when the coke was at fault, and for this reason he would like to know whether the authors had been able to evolve, as a result of these experiments, any improved method of "truck to truck" checking of coke supplies.

With reference to coke size, to which the authors referred, he agreed that large coke was preferable to small coke, even if the large coke had to be broken for use. He understood this to be because coke with good shatter value did not break up very much in transit. Another rough check on the strength of coke was to examine the dump at the end of the melt. This gave an indication of how the coke had stood up to the cupola conditions.

MR. PEARCE said it was very difficult to arrive at a definite figure for cokes and Table XIV gave the best possible statement with regard to the average form of the individual pieces. One of the earlier pieces of work referred to in the introduction was concerned with coke size and the authors did arrive at a conclusion. For a given size of cupola there was an optimum size of coke, but practically speaking it was difficult for foundrymen to control the size of coke. If bad, it got smaller in transit, and, if large, it was probably good, and it was doubtful whether it would break up in transit.

Continuing, Mr. Pearce said Dr. O'Neill had told him that the L.M.S.R. had not altered its procedure with regard to truck to truck checking. Mr. Russell's question was a pertinent one and the best result could be got out of this Paper by finding the best way of checking coke as deliveries were received. It was practically impossible to apply Rose's test as a routine test. The cokes which caused bad reports from the foundry were those which showed the variability of structure from sample to sample, under that test. The time distance from Ca to Cc was about two years and showed variability in coal and process of carbonisation.

MR. RUSSELL pointed out that the journey which the coke had to undergo was in itself a form of shatter test.

Shatter Testing

MR. BRADLEY said that in the shatter test which he had found to be most consistent, the size of the coke definitely did affect the result, and small coke contents tended to give a high result and in that way the test was not too satisfactory. It was quite true that the shatter index, speaking generally, was the best test. He thought if he had a shatter index of not less than 80 on a 2-in. screen and not less than 90 per cent. fixed carbon, one could generally assume the cupola would run quite satisfactorily.

Small Coke and Loss of Melting Efficiency

MR. J. HIRD said a recent personal experience was rather interesting. He had trouble with cold iron and iron in the tuyeres. Finding that in the coke there was a lot of small pieces he tried a run the next day, but eliminated the small coke. He had exceptionally hot metal and no sign of iron in the tuyeres.

MR. PEARCE asked whether the coke was screened or hand-picked.

MR. HIRD said it was hand-picked, eliminating pieces below 3 in. by 3 in.

MR. PEARCE thought that was a very important point and actually bore upon blast-furnace practice, where the temperature rose if the fines were eliminated. He was indebted to Mr. Hird for making that point. Mr. Bradley's suggestion of 80 per cent. on a 2-in. screen for a shatter test formed a good working basis for coke without involving too much time in testing.

MR. J. K. SMITHSON said some years ago he screened several trucks of blast-furnace coke and analysed the smalls separately, finding them to be very considerably higher in ash than the large coke. This factor no doubt explained to some extent the improvement in cupola working to which Mr. J. Hird referred when he had separated the smalls from his coke.

Mr. Smithson in a written communication gave figures (Table A) for three makes of average quality Durham Patent blast-furnace coke, showing the proportions of material under ½ in., over ½ in. and under 1½ in., and over 1½ in., together with the complete analysis of each size. The higher ash content of the smaller material is very marked, and it would seem that the value of this material in the cupola is very small, and taking into consideration the probable detrimental effects it seems that it will be well worth while to discard the smalls, which can be generally used for drying stoves, etc.

The higher ash content of the small coke seems to indicate or suggest that the tendency to breaking in handling and service may be in some degree connected with the size and distribution of the ash particles, and that this is a field for future investigation. Possibly the practical man who is not in a position to make chemical and physical tests of his coke will find that a record of the small coke from various makes will provide him with a fairly reliable criterion of their comparative merits.

MR. PEARCE said these figures were very valuable. It was obvious that screening could be applied to many foundries without wasting any of the consignment, because the small coke could be used up elsewhere.

A MEMBER said if slag were covering coke, it would have the result of improving the combustion of coke, and he asked if the different types of coke could be screened and the different effects given.

MR. PEARCE suggested that Mr. Smithson's figures indicated what would be expected if this were done, in the light of Mr. J. Hirds' experience.

A MEMBER raised the question of taking gas analyses at different levels in the furnaces, and MR. PEARCE said that had never been done, although it has been suggested and considered. In dealing with gas from a cupola, one was faced with not having the same conditions from point to point either horizontally or vertically. The furnace never seemed to arrive at the condition of equilibrium. Not only from point to point in the stack, but from instant to instant, there were changes in the analyses of the gas, and at present a personal view was that one could not attach much importance to cupola gas analyses. Done on a sufficient scale it would be justified.

Cupola Gas Analysis

MR. COOPER said a method adopted in Germany was to take an ordinary sleeve brick and insert it at 45 degrees in the cupola approximately 4 ft. above the top tuyere. When the CO_2 was ranging from 16 to 18 per cent. and after the cupola has been blown in the test for gas was made, and it was so run until the cupola was blown down. A sleeve brick was used in conjunction with an ordinary iron tube and the gas could be taken through to the CO_2 recorder or gas apparatus. This was a most satisfactory method and quite reliable.

A vote of thanks was passed to the authors on the proposition of MR. COOK.

The Institute of Metals

ANNUAL AUTUMN MEETING IN SHEFFIELD

As previously announced, the Twenty-ninth Annual Autumn Meeting of the Institute of Metals will be held in Sheffield from September 6 to 9, by the kind invitation of the Sheffield Local Section of the Institute, with the cordial co-operation of the industrialists of Sheffield and the University of Sheffield. The headquarters of the Institute, and the office of the honorary local secretary, will be in the Department of Applied Science, the University, St. George's Square, Sheffield, 1, where all the meetings will be held. An influential reception committee (of which the chairman is Prof. J. H. Andrew, D.Sc., and the honorary secretary is Mr. E. J. Thackeray) has been formed to carry out the arrangements. An outline of the programme is given below.

MONDAY, SEPTEMBER 6.

2.30 to 7.15 p.m.—The office of the honorary local secretary will be open at the Department of Applied Science, St. George's Square, for the issue of tickets, badges, etc., and for general information.

7.15 for 7.30 p.m.—Reception of members at the Department of Applied Science by the Lord Mayor of Sheffield (Councillor Mrs. A. E. Longden, J.P.), the Senior Pro-Chancellor (Lieut.-Colonel Sir H. K. Stephenson, Bart., D.S.O., D.L., LL.D., J.P.) and the Vice-Chancellor of the University of Sheffield (Dr. A. W. Pickard-Cambridge, M.A., D.Litt., LL.D.). (Evening dress.)

8.0 p.m.—Short business meeting, followed by the Sixteenth Autumn Lecture on "Metallurgy and the Aero Engine," by Dr. D. R. Pye, C.B., M.A., F.R.S. (Deputy Director of Scientific Research, Air Ministry).

9.30 to 11 p.m.—Light refreshments and music.

TUESDAY, SEPTEMBER 7.

9.0 a.m. to 12 noon.—The office of the honorary local secretary will be open.

10.0 a.m. to 12.30 p.m.—The following Papers will be presented for discussion:—

"Copper-Rich Nickel - Aluminium - Copper Alloys. Part I—The Effect of Heat-Treatment on Hardness and Electrical Resistivity." By W. O. Alexander and D. Hanson.

"The Constitution of the Nickel-Aluminium System." By W. O. Alexander and N. B. Vaughan.

"The Methods of Testing Zinc Coatings." By L. Kenworthy.

"The Mechanical Properties of Some Metals and Alloys Broken at Ultra High Speeds." By D. W. Ginns.

"Precision Extensometer Measurements on Tin." By B. Chalmers.

If time permit:—

"Alloys of Magnesium. Part VI—The Constitution of the Magnesium-Rich Alloys of Magnesium and Calcium." By J. L. Haughton.

10.0 a.m.—Ladies will leave the Department of Applied Science for a visit to the Dukeries (including Welbeck) and Firbeck Hall Club, where lunch and tea will be taken. The party will arrive back in Sheffield at about 5.30 p.m.

12.30 p.m.—Members will be conveyed to the Royal Victoria Station Hotel.

1.0 p.m.—Luncheon at the Royal Victoria Station Hotel.

2.0 p.m.—Members will depart from the Royal Victoria Station Hotel for works visits, as follows:—The United Steel Companies, Limited (Templeborough Works); the English Steel Corporation, Limited (number limited to 25); Brown, Bayley's Steel Works, Limited (number limited to 40); Mellowes & Company, Limited (number limited to 20).

8.0 p.m. to midnight.—Members and their ladies will attend a reception at the Town Hall, by the kind invitation of the Lord Mayor of Sheffield. (Evening dress, with decorations.)

WEDNESDAY, SEPTEMBER 8.

10.0 a.m. to 12.30 p.m.—The following Papers will be presented for discussion:—

"A Study of the Deformation of the Macrostructure of Two-Phase Alloys by Cold Rolling." By H. A. Unckel.

"The Transformation in the Beta Brasses." By C. Sykes and H. Wilkinson.

"A Study of the Mechanical Properties of Tin-Rich Antimony-Cadmium-Tin Alloys." By D. Hanson and W. T. Pell-Walpole.

"The Determination of Alumina in the Presence of Metallic Aluminium." By G. B. Brook and A. G. Waddington.

If time permit:—

"The Constitution of Tin-Rich Antimony-Cadmium-Tin Alloys." By D. Hanson and W. T. Pell-Walpole.

"The Constitution of the Copper-Gallium Alloys in the Region 18 to 32 Atomic per cent. Gallium." By W. Hume-Rothery and G. V. Raynor.

10.30 a.m.—Ladies will leave St. George's Square for a visit to the food factory of Arthur Davy & Sons, Limited.

12.30 p.m.—Members and their ladies will be conveyed to the Royal Victoria Station Hotel.

1.0 p.m.—Luncheon at the Royal Victoria Station Hotel.

2.0 p.m.—Members will depart from the Royal Victoria Station Hotel for works visits, as follows:—Thos. Firth & John Brown, Limited (number limited to between 30 and 40); Edgar Allen & Company, Limited (number limited to 20); Hadfields, Limited (East Hecla Works) (number limited to 50); Walker & Hall, Limited (ladies may visit these works).

2.0 p.m.—Ladies will leave the Royal Victoria Station Hotel for a visit to the Snowite Laundry (number limited to 50), or Walker & Hall, Limited.

7.30 p.m. to 1.0 a.m.—Banquet and dance at the Royal Victoria Station Hotel. (Evening dress, with decorations.)

THURSDAY, SEPTEMBER 9.

10.0 a.m.—Members and their ladies will be conveyed through some of the beauty spots of Derbyshire. Luncheon will be served at the Palace Hotel, Buxton. Tea will be taken at a convenient hotel on the return journey (at the invitation of Prof. and Mrs. J. H. Andrew), arrival back in Sheffield being timed for about 6.30 p.m.

8.30 p.m. to 10.30 p.m.—If desired, arrangements can be made for members and their ladies (number limited to 80) to attend the dinner cabaret at the Grand Hotel. The cost of this is 6s. per head, and is additional to the social functions fee.

Further details of this annual meeting are obtainable on application to the secretary, Mr. G. Shaw Scott, 36, Victoria Street, London, S.W.1.

Catalogue Received

Foseco News No. 5. Issued by Foundry Services, Limited, 285, Long Acre, Nechells, Birmingham, 7, this publication covers some phases of the casting of nickel and nickel alloys, "Corecoat," recently dealt with in our columns, and an illustrated description of plungers for adding sodium and other materials to liquid metals contained in crucibles.

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This Week's News in Brief

Trade Talk

THE EAST RAND ENGINEERING COMPANY, LIMITED, of Klerksdorp, South Africa, is erecting a new foundry.

YESTERDAY, THE NEW spring department of Samuel Fox & Company, Limited, of Stocksbridge, was inspected by representatives of the technical Press.

THE EXTENSION to the Derby Technical College will be opened by Mr. A. F. Sidgreaves, managing director of Rolls-Royce, Limited, on September 9.

THE BRIGHTSIDE FOUNDRY & ENGINEERING COMPANY, LIMITED, Sheffield, propose to increase the authorised capital from £150,000 to £250,000 by the creation of 100,000 £1 ordinary shares.

PART OF THE ROOF of the drawing offices of William Beardmore & Company, Limited, Duke Street, Glasgow, was damaged by fire last week, but business will be carried on as usual.

A SCHEME OF ARRANGEMENT made between the Renishaw Iron Company, Limited, and its preference and ordinary shareholders has been sanctioned, and a reduction of capital from £130,000 to £82,150 confirmed.

FERGUSON BROS., LIMITED, Port Glasgow, are to build two dredgers, one for the London Midland & Scottish Railway and the other for the Wellington Harbour Board, New Zealand. The company will also build the machinery for both vessels.

ACCORDING TO THE "Engineer and Foundryman" (South Africa), Steel Ceilings & Aluminium Works, Limited, is the only concern in the Dominion to manufacture grey-iron castings using the electric furnace as a melting medium. The unit employed is a 7½-ton Heroult furnace.

SAGMA, LIMITED, of 110, Fenchurch Street, London, E.C.3, have been appointed sole United Kingdom representatives for the Comptoir des Fontes Hematites, Paris. This latter concern is the sole seller of hematite produced by French furnaces and is at present in a position to give prompt deliveries.

MR. F. H. CLARK, late partner in the firm of H. Clark & Sons, of Clapton, is building a new foundry at Southerland Road, Blackhorse Lane, Walthamstow, London, E.17. Production will be started about the middle of August, and it is intended to manufacture pianoforte frames and general castings. The telephone number is Larkspur 2000.

ACCORDING TO THE "Financial Post" (Toronto), the International Nickel Company of Canada, Limited, will commence immediately the sinking of a vertical shaft at the Levack mine in Northern Ontario. The shaft will be sunk to 2,000 ft., and will cost about £500,000. Operations at the Levack mine (formerly owned by the Mond Nickel Company, Limited) were resumed last March after suspension since 1931.

AT A CONFERENCE of the executives of thirty-seven engineering trade unions, held in London on Tuesday, it was decided to recommend the employees to accept the employers' offer for wage increases and other improvements in working conditions. The proposed agreement, which is to date from August 23, provides for (1) each man to be credited with an *ex-gratia* allowance of one-fiftieth of each week's wages, dating from the date of operation of the agreement, the allowance to be accumulated in a special fund and paid out at the holiday period; (2) an increase of 3s. a week for all adult workers, payable in instalments of 1s. 6d. from August 23 and 1s. 6d. from November 15; (3) an increase from time and a-quarter to time and a-third for the first two hours of day-shift overtime; and (4) the setting up of a committee to discuss the possibility of consolidating national bonuses. Further clauses deal with local wages claims and the avoidance of disputes.

British Foundry School

The annual meeting of the British Foundry School was held last Tuesday, in Birmingham. The annual report, which will be abstracted in our next issue, showed that the foundry industry is giving inadequate support. In Germany there are 100 students per annum attending foundry schools, as against five in this country. Mr. R. G. Hosking was re-elected chairman; Alderman W. Byng-Kenrick, vice-chairman; Mr. J. G. Pearce, honorary adviser and treasurer; and Mr. G. H. Rogers, secretary.

Personal

CAPT. B. M. M. HUDSON has been elected Master of the Ironmongers' Company. The Wardens are Mr. A. K. Steven and Dr. A. B. Gordon.

MR. PERCY ELLIOTT has been appointed secretary of the Butterley Company, Limited. Mr. Elliott has been on the staff of the secretary's department for over twenty years.

MR. RICHARD HOLT has been appointed manager of the magnet department of Edgar Allen & Company, Limited, in place of Mr. H. E. Kershaw, who has resigned. Mr. Kershaw will, however, continue to act for the firm as a consultant.

MR. FRANK HUDSON has resigned his position on the staff of Glenfield & Kennedy, Limited, of Kilmarnock, to join the research and development department of the Mond Nickel Company, Limited. His main activity will be in the direction of helping the non-ferrous side of the foundry industry.

MR. P. E. RENTSCHLER, President of the Hamilton Foundry & Machine Company, has been elected President of the American Grey Iron Founders' Society. Mr. R. E. Kucher, Vice-President, Olympic Foundry Company, has been elected Vice-President; Mr. J. H. Pohlman, Vice-President, Pohlman Foundry Company, secretary; and Mr. W. L. Seelbach, secretary-treasurer, Forest City Foundries Company, treasurer.

MAJOR J. G. BULLEN, J.P., manager of the Kinlochleven and Lochaber works factories of the British Aluminium Company, Limited, has removed from Kinlochleven, and taken up residence at Fort William. Mr. W. B. C. Perrycoste, who has been appointed deputy-manager at both factories, resides at Kinlochleven at present. Mr. W. Henkel is assistant manager at Kinlochleven, and Mr. D. M. Fraser, assistant manager at Lochaber. Mr. William C. Kennedy has been appointed works engineer at Kinlochleven in succession to the late Mr. J. A. V. Thomson, and Mr. R. M. Sumpner and Mr. A. D. Mackie are his assistants.

Will

WALKER, CHARLES C., retired director of Walker Steel Works, Limited, Sheffield £133,388

Obituary

MAJOR-GENERAL SIR WILLIAM GEORGE BERTRAM BOYCE, a director of Rolls-Royce, Limited, has died, aged 69.

MR. HENRY MEADOWS, founder and chairman of Henry Meadows, Limited, gear case manufacturers, of Wolverhampton, died last Monday, aged 57.

MR. GEORGE EDWARD HENDERSON, well known in Newcastle-upon-Tyne, has died at the age of 93. Among other business connections, he was a director of the Redheugh Bridge Company, Limited.

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Gendrum, Limited, 22-26, Burgess Street, Sheffield.—Capital, £250. Ironfounders. Directors: T. Meldrum and T. C. Vere.

W. James (Wolverhampton), Limited.—Capital, £2,000. Ironfounders, brassfounders, etc. Directors: W. A. James, Rydall Mount, Fowler Street, Wolverhampton; and D. Pincott.

Warwill, Limited.—Capital, £15,000. To take over the Warwill Foundry, Abertillery, Mon. Directors: J. H. Cole, The Woodlands, Oak Street, Abertillery, Mon.; G. S. Phillips, and B. Cole.

Company Report

W. & T. Avery, Limited.—Net profit for year to March 31, £166,645; brought in, £62,391; available, £229,037; dividend of 10 per cent., making 15 per cent. for the year; general reserve, £45,000; pensions fund reserve, £10,000; carried forward, £65,079.

Patent Specifications Accepted

The following list of Patent Specifications accepted has been taken from the "Official Journal (Patents)." Printed copies of the full Specifications are obtainable from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each. The numbers given are those under which the Specifications will be printed and abridged, and all subsequent proceedings will be taken.

464,265. STEVENS, A. H. (United Engineering & Foundry Company). Bearing arrangements for rolling mills.
464,425. MALAM, J. E., and IMPERIAL CHEMICAL INDUSTRIES, LIMITED, Heat-treatment of metals.
464,482. KUHN, P. Production of steel in the Thomas converter.
464,513. BRASSERT & COMPANY, LIMITED, H. A., and BRASSERT, H. A. Manufacture of rolled metal sheets.
464,549. SCHOEMANN AKT.-GES. Automatic winding of strip iron on to reels.
464,596. DEUTSCHE EDELSTAHLWERKE AKT.-GES. Articles made of non-magnetic steels.
464,608. AMERICAN FOUNDRY EQUIPMENT COMPANY. Abrasive throwing apparatus.
464,656. RIVOCHE, E. Process of blackening iron and steel, and protecting the same from rust.
464,675. WHITE, HUGUES, & COMPANY, LIMITED, and PHILY, F. DE. Process and apparatus for the extraction of metal from ores.
464,777. JONES, E. H., and WILLIAMS, S. Uniting metal parts by casting.
464,817. STEVENS, A. H. (United Engineering & Foundry Company). Manufacture of articles such as welding rods out of rim steel.
464,818. STEVENS, A. H. (United Engineering & Foundry Company). Apparatus for manufacturing long thin pieces of hot-rolled metallic strip.
464,901. KRUPP AKT.-GES., F. Manufacture of composite cast-metal rolls.
464,917. BJORKMAN, E. B. Method of and apparatus for producing granulate of blast furnace slag for the manufacture of white cement and plaster.
464,961. SOC. ANON. DES HAUTS-FOURNEAUX DE LA CHIERS. Devices for hardening rails.
465,117. DAY, J. Moulds for casting metals.
465,121. QUINNEY, H., and INGLIS, C. E. Tensile and like testing-machines.

Output of Pig-Iron, Steel and Finished Products

The British Iron and Steel Federation, in its Statistical Bulletin for June, 1937, reports that production of pig-iron and ferro-alloys in June amounted to 699,300 tons. This compares with 696,300 tons in the preceding month and 644,100 in the corresponding month of 1936, and reflects increases in the daily rate of production of 3.5 per cent. and 8.5 per cent. respectively. Production in the first half of 1937 has exceeded by 6.8 per cent. the output attained during January-June, 1936. Production of steel ingots and castings during June was 1,106,400 tons, as against 1,047,300 tons in May and 965,900 tons in June, 1936. Output is still expanding and during the first six months of this year has exceeded by 10.4 per cent. the production achieved in the corresponding period of 1936.

Contracts Open

Dunton, August 9.—Supply and laying of 6,500 yds. of 12-in. dia. spun-iron pipes, for the Biggleswade Water Board. Binnie, Deacon & Gourley, engineers, Artillery House, Artillery Row, Westminster, S.W.1. (Fee £5, returnable.)

Southend-on-Sea, August 11.—44 tons of 9-in. internal dia. cast-iron and spun-iron pipes, for the Town Council. Mr. R. H. Dyer, borough engineer, Municipal Buildings, Clarence Road. (Fee £1, returnable.)

Ashford, August 11.—Pumping plant, including electrically-driven motors, for the Urban District Council. The Surveyor, 5, North Street, Ashford, Kent.

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Raw Material Markets

The iron and steel works are extending an even heartier welcome than is usual to the advent of the holiday period this year, as it is hoped to decrease delivery arrears as much as possible while the consuming plants are idle. The demand for new business appears to be rather less insistent, but producers, in any case, are not in the position to further their commitments in existing circumstances.

Pig-Iron

MIDDLESBROUGH.—There is little likelihood of any increase in the production of Cleveland iron in the near future; basic iron for the steel furnaces generally is being made in this area. Consumers are aided by supplies from other districts, while imports from abroad are on an increasing scale. No. 3 Cleveland G.M.B. is quoted at 101s., No. 1 foundry at 103s. 6d., and No. 4 forge and No. 4 foundry at 100s. per ton, delivered in the Middlesbrough district. In spite of the fact that very few can be accepted, inquiries for hematite from abroad are still coming in. Producers could obtain much higher prices for export than are received for home trade, but loyalty to consumers in this country is being exercised. Furnaces are working to full capacity, but producers still have considerable leeway to make up on their contractual commitments. For delivery on the North-East Coast ordinary mixed numbers are quoted at 122s. 6d. per ton, 128s. in Sheffield, and 133s. 6d. in the Midlands.

LANCASHIRE.—Light-castings makers, machine-tool makers, heavy electrical engineers and textile machinists are all well situated for orders and are taking deliveries of pig-iron as they become available. Activity at the machine-tool makers' plants has increased considerably within recent months. Offers of Derbyshire and Staffordshire brands of No. 3 foundry iron for delivery in the Lancashire price zone are on the basis of 109s. per ton, with Northants at 107s. 6d. and Derbyshire forge iron at from 104s. to 106s., according to the class of consumer. For delivery equal to Manchester, West Coast hematite is quoted at 131s., and East Coast material at 130s.; Scottish No. 3 foundry at 130s. per ton is largely nominal.

MIDLANDS.—The delivery position is now somewhat easier, but makers continue to meet with considerable pressure for supplies. Producers are despatching iron as it becomes available, and there are no stocks whatever with which to face the customary increased activity in the autumn. Northants No. 3 iron is still quoted at 103s. 6d., with Derbyshire, Lincolnshire and North Staffordshire No. 3 at 106s., delivered to Birmingham and Black Country stations. An additional 11d. per ton is charged if delivered into works. Heavy engineering, motor and machine-tool makers continue to exert pressure for supplies of low-phosphorus pig-iron. In view of the fact that this material comes from various districts, prices range from £6 10s. to £7 5s. per ton, delivered the Midlands. At the present time few transactions are being made with Continental or American sellers of foundry pig-iron, but a revival of this trade is expected within the next few weeks. There is little change in the hematite market from week to week. East Coast No. 3 is quoted at £6 13s. 6d. and West Coast mixed numbers at £6 14s. 6d., delivered the Midlands. An additional 1s. 6d. per ton is charged if delivery into works is stipulated.

SCOTLAND.—Local blast furnaces have taken the opportunity of the Fair holiday to make some headway in overtaking their delivery arrears. Imports of iron continue to be made on an extensive scale. No. 3 foundry iron is quoted at 113s. f.o.t. furnaces, with No. 1 at 115s. 6d. Cleveland No. 3 is quoted at 104s. f.o.t. Falkirk and 107s. f.o.t. Glasgow. The charge for East Coast, West Coast and Scottish hematite remains at 123s., less rebate, with basic, British and Indian 100s., and Scottish basic at 107s. 6d., all delivered steelworks and less usual rebate.

Coke

There is no change in the prices of foundry coke as yet, but further advances are generally anticipated. For delivery to Birmingham and district, the minimum price for Durham or Welsh coke is 50s. to 51s., while the better qualities are quoted up to 62s. 6d. per ton.

Steel

The volume of new business in the steel market continues to be restricted by the difficulty of finding manufacturers who are in a position to accept orders for delivery within a reasonable period, says the official report of the London Iron and Steel Exchange. The quietness of the market is accentuated by the holiday conditions ruling in the producing districts, although outputs are being maintained at a higher rate. Great stringency continues to rule in the semi-finished steel section, although the British production of this class of steel is being pressed to the utmost. Operations at the consuming works are being restricted by the difficulty of obtaining supplies, but it is hoped that the situation in this respect will be improved later on by the arrangements which have been made for increasing imports. In the finished-steel department, the pressure to obtain deliveries is not quite so severe owing to the holidays, but many consumers are endeavouring to cover their future requirements for several months ahead. In some cases contracts have been entered into for delivery over the early part of 1938, but few makers or consumers care to commit themselves so far ahead in the prevailing conditions.

Scrap

While in some districts there appears to be easier conditions prevailing in the scrap market, considerable difficulty is still being experienced elsewhere in procuring adequate supplies. Better tonnages are available in the Cleveland area, as also is the case in Yorkshire and Scotland. This is generally due to the fact that substantial tonnages have arrived from abroad. Consumers are quite willing to pay the full maximum prices where there is the chance of securing further supplies.

Metals

Holiday influences seem to have been to the fore in the non-ferrous metal markets during the past week, although conditions generally are quite firm and satisfactory for the time of the year.

Copper.—The weekly market report issued by Brandeis, Goldschmidt & Company, Limited, states that "considering that the holiday season is now on, the demand for copper has been quite good. The demand has been largely for nearby electro copper, and the spread between standard and electro is still unduly high. The backwardation on standard has also reappeared, due partly to the metal being taken from warehouse, but, in view of the statistical position, this tendency does not seem justified. There has been no confirmation of proposals regarding the re-introduction of restriction, but the fact that producers apparently have a scheme ready has restored confidence in the price for the time being." Quiet conditions are likely to rule until the autumn, when consumers are expected to negotiate for substantial tonnages, as, generally speaking, they are not well situated for stocks. Inquiry from the Continent is not active, while business in the United States remains dull, but with a satisfactory outlook.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £56 10s. to £56 12s. 6d.; Friday, £56 11s. 3d. to £56 13s. 9d.; Monday, £56 17s. 6d. to £56 18s. 9d.; Tuesday, £56 12s. 6d. to £56 15s.; Wednesday, £56 16s. 3d. to £56 18s. 9d.

Three Months.—Thursday, £56 5s. to £56 6s. 3d.; Friday, £56 7s. 6d. to £56 10s.; Monday, £56 13s. 9d. to £56 15s.; Tuesday, £56 8s. 9d. to £56 10s.; Wednesday, £56 13s. 9d. to £56 16s. 3d.

Tin.—The July issue of the International Tin Research and Development Council's Bulletin, published by The Hague Statistical Office, indicates that world production of tin in the first five months of the current year totalled 75,477 tons. World production for the year ended May, 1937, was 184,818 tons, against 160,337 tons in the preceding year. The corresponding statistics of tin consumption for these periods were respectively 175,627 tons and 156,329 tons. World visible stocks of tin decreased by 588 tons in June, 1937, to 22,439 tons, compared with a level of 15,536 tons at the end of June, 1936. A subdued tone has developed in this market, and the outlook is not too cheerful. World inquiry is steady, but there appears to be little likelihood of any marked expansion in the near future at any rate. It is understood that British (Non-ferrous) Mining Corporation is sponsoring a scheme for developing Cornish tin mines. It is proposed to acquire prospecting rights over a large area of Cornwall with the option to take mining leases. The exploration of existing setts would be carried out as well as prospecting for new lodes. The company is willing to spend £30,000 to £40,000 in prospecting. Negotiations with most of the mining rights owners, including the Duchy of Cornwall, have already been concluded, but Lord Falmouth, one of the largest owners, is in dispute over the best method of mining. Lord Falmouth has agreed to lease his property if the corporation agrees to work the setts separately, to use the county adit and do not hole from one mine to another.

Conversation in the tin section of the London Metal Exchange and also throughout the world is largely devoted to the question of a new buffer pool. Undoubtedly, the subject is shrouded in no uncertain degree of mystery in official quarters, but it is generally accepted that there will be no revival of the pool for several months at the least. At the formation of the last pool Malaya was eventually persuaded to agree with the other interested parties, but it is most unlikely that this would again happen. Amsterdam tin quarters appear to be the chief, if not the only, advocates of the scheme. Earlier in the week there was a report from Amsterdam to the effect that the International Tin Committee were actually engaged in drafting details of a "reserve stock organisation" to take the form of accumulating all available stocks.

Official quotations have been as follow :—

Cash.—Thursday, £264 10s. to £265 10s.; Friday, £262 10s. to £263; Monday, £264 10s. to £265; Tuesday, £262 15s. to £263; Wednesday, £262 to £262 10s.

Three Months.—Thursday, £262 to £262 5s.; Friday, £260 10s. to £261; Monday, £261 to £261 5s.; Tuesday, £258 5s. to £258 10s.; Wednesday, £260 10s. to £261.

Spelter.—World smelter output of spelter is increasing, as is indicated by the statistics of the Metallgesellschaft. Output in May totalled 145,981 metric tons, making 667,099 tons for the first five months of the year, as compared with 606,478 tons in the corresponding period of last year. The market in this country has developed a quieter tone. Imports into the United States are heavy.

Daily market prices :—

Ordinary. — Thursday, £28 5s.; Friday, £21 18s. 9d.; Monday, £22 13s. 9d.; Tuesday, £22 7s. 6d.; Wednesday, £22 15s.

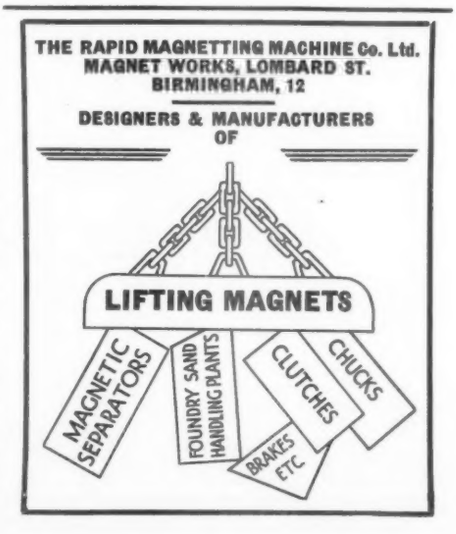
Lead.—Trade demand is not substantial at the present time, owing to the seasonal industrial quietude, but improved conditions are likely to materialise in the early autumn.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £23 2s. 6d.; Friday, £23 8s. 9d.; Monday, £23 7s. 6d.; Tuesday, £22 13s. 9d.; Wednesday, £22 13s. 9d.

Scrap.—Business remains on a substantial basis, and consumers are displaying the customary pre-holiday interest in scrap metal. Prices are firm.

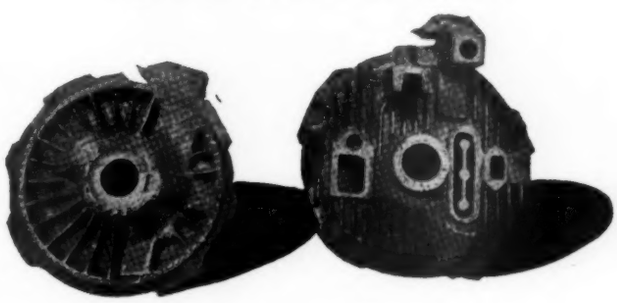
Approximate selling prices for old metal:—New aluminium cuttings, £82; rolled, £67; cast, £43; die cast, £46. Heavy, clean copper, £56; braziery, £49; light, £51. Heavy brass, £36 to £37; light, £32. Zinc, £15. Lead, soft, sheet and pipe, £23 10s. Gunmetal, £53.



There are various grades of YORKSHIRE SAND

Yorkshire Sand is of a synthetic nature, its production being under careful laboratory control. Perfect standardization is obtained with the various grades, suitable for light and the heaviest steel castings.

It is because of the refractability of the sand and of the toughness of the mould surface that castings made with Yorkshire Sand are distinguishable by their excellent finish.



YORKSHIRE SAND

for "easy stripping"

Information regarding the most suitable grades of Yorkshire Sand for your particular needs and full technical details will be given without obligation.

SOLE PRODUCERS

GENERAL REFRACTORIES LTD.,

TELEPHONE: SHEFFIELD 31113 (6 LINES)

Genefax House, Sheffield

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Other Moulding Sands include—Zenith Red Sand, York Yellow 102 Sand, Scottish Rock Sand, Bramcote Red Sand, Harperley Sand, Hensall Sand, Red Rover Sand, Warsop Sand, Mansfield Sand.

RAW MATERIALS—PRICE LIST

(Wednesday, July 28, 1937)

COPPER

	£	s.	d.
Standard cash	56	16	3
Three months	56	13	9
Electrolytic	64	0	0
Tough	62	15	0
Best selected	63	5	0
Sheets	93	0	0
India	74	5	0
Wire bars	64	10	0
Ingot bars	64	10	0
H.C. wire rods	67	15	0
Off. av. cash, June	55	15	$6\frac{3}{22}$
Do., 3 mths., June	55	2	$11\frac{5}{11}$
Do., Sttlmnt., June	55	15	$2\frac{5}{11}$
Do., Electro, June	62	5	$10\frac{10}{11}$
Do., B.S., June	62	6	$4\frac{1}{2}$
Do., wire bars, June	63	3	$7\frac{1}{11}$
Solid drawn tubes			$14\frac{1}{2}$d.
Brazed tubes			$14\frac{1}{2}$d.
Wire			$10\frac{1}{2}$d.

BRASS

Solid drawn tubes	$12\frac{1}{2}$d.
Brazed tubes	$14\frac{1}{2}$d.
Rods, drawn	$11\frac{1}{2}$d.
Rods, extd. or rlld.	$7\frac{1}{2}$d.
Sheets to 10 w.g.	10d.
Wire	$9\frac{1}{2}$d.
Rolled metal	$9\frac{1}{2}$d.
Yellow metal rods	$7\frac{1}{2}$d.

TIN

	£	s.	d.
Standard cash	262	0	0
Three months	260	10	0
English	262	10	0
Bars	264	0	0
Straits	263	10	0
Eastern	259	7	6
Banca (nom.)			—
Off. av. cash, June	249	19	$10\frac{7}{11}$
Do., 3 mths., June	249	3	$4\frac{10}{11}$
Do., Sttlmt., June	249	19	$9\frac{3}{11}$

SPELTER

	£	s.	d.
Ordinary	22	15	0
Remelted	20	0	0
Hard	19	0	0
Electro, 99.9	25	6	3
English	23	7	6
India	20	0	0
Zinc dust	30	0	0
Zinc ashes	7	10	0
Off. aver., June	21	9	$4\frac{1}{2}$
Aver. spot, June	21	8	$2\frac{2}{11}$

LEAD

	£	s.	d.
Soft foreign, ppt.	22	13	9
Empire (nom.)	23	11	3
English	24	10	0
Off. aver., June	22	16	$4\frac{4}{11}$
Aver. spot, June	22	17	$6\frac{6}{22}$

ALUMINIUM

Ingots	£100 to £105
Wire	1/3 to 1/4 lb.
Sheet and foil	1/2 to 1/4 lb.

ZINC SHEETS, &c.

Zinc sheets, English	36	0	0 to	36	10	0
Do., V.M. ex-whse.	36	0	0 to	36	10	0
Rods				30	0	0

ANTIMONY

English	82	10	0 to	83	10	0
Chinese, ex-whse.				70	0	0
Crude, c.i.f.				36	0	0

QUICKSILVER

Quicksilver				13	10	3

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—	
25%	£14 10 0
45/50%	£12 0 0
75%	£17 0 0
Ferro-vanadium—	
35/50%	12/8 lb. Va
Ferro-molybdenum—	
70/75% carbon-free	4/9 lb. Mo.
Ferro-titanium—	
20/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£21 to £22
Ferro-tungsten—	
80/85%	5/3 lb. (nom.)
Tungsten metal powder—	
98/99%	$5/4\frac{1}{2}$ lb. (nom.)
Ferro-chrome—	
2/4% car.	£34 15 0
4/6% car.	£24 5 0
6/8% car.	£24 0 0
8/10% car.	£24 0 0
Ferro-chrome—	
Max. 2% car.	£36 0 0
Max. 1% car.	£38 5 0
Max. 0.5% car.	£41 0 0
70% carbon-free	10d. lb.
Nickel—99.5/100%	£180 to £185
"F" nickel shot	£165 0 0
Ferro-cobalt, 98/99%	8/6 lb.
Metallic chromium—	
96/98%	2/5 lb.
Ferro-manganese—	
76/80% loose	£18 15 0 to 19 5 0
76/80% packed	£19 15 0 to 20 5 0
76/80% export	£22 0 0
Metallic manganese—	
94/96% carbon-free	1/3 lb.

Per ton unless otherwise stated, basis 2-ton lots.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	2s. 7d.
Finished bars, 18% tungsten	3s. 6d.

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under $\frac{1}{2}$ in. to $\frac{1}{4}$ in.	3d. lb.
Do., under $\frac{1}{4}$ in. to $\frac{3}{16}$ in.	1/- lb.
Flats, $\frac{1}{2}$ in. × $\frac{1}{4}$ in. to under 1 in. × $\frac{1}{4}$ in.	3d. lb.
Do., under $\frac{1}{2}$ in. × $\frac{1}{4}$ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

	£	s.	d.	£	s.	d.
South Wales (West)—						
Heavy steel, best	3	8	0	to 3	10	0
Mixed iron and steel	3	5	0	to 3	7	6
Heavy cast iron	3	8	0	to 3	10	0
Good machinery				4	0	0
Cleveland—						
Heavy steel, best	3	6	6	to 3	9	0
Steel turnings				2	15	0
Heavy cast iron				4	7	6
Heavy machinery				4	10	0
Midlands—						
Short heavy steel	3	17	6	to 4	0	0
Light cast-iron scrap				3	5	0
Heavy wrought iron	4	0	0	to 4	5	0
Steel turnings	2	2	6	to 2	5	0
Scotland—						
Heavy steel, best	3	4	6	to 3	7	0
Ordinary cast iron				4	7	6
Cast-iron borings	2	0	0	to 2	2	6
Wrot-iron piling	4	13	6	to 4	15	0
Heavy machinery	4	13	6	to 4	15	0

London—Merchants' buying prices, delivered yard.

Copper (clean)	47	0	0
Brass	30	0	0
Lead (less usual draft)	20	0	0
Tea lead	14	10	0
Zinc	14	10	0
New aluminium cuttings	74	0	0
Braziery copper	41	0	0
Gunmetal	45	0	0
Hollow pewter	165	0	0
Shaped black pewter	125	0	0

PIG-IRON

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	103/6
,, No. 3	101/-
,, No. 4	100/-
Forge No. 4	100/-
Hematite No. 1	123/-*
Hematite M/Nos.	122/6*
N.W. Coast—	
Hem. M/Nos. d/d Glas.	123/-*
,, d/d Birm.	134/6*
Malleable iron d/d Birm.	160/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	103/-
,, No. 3 fdry.	106/-
Northants forge	100/6
,, fdry. No. 3	103/6
,, fdry. No. 1	106/6
Derbyshire forge	103/-
,, fdry. No. 3	106/-
,, fdry. No. 1	109/-
Scotland—	
Foundry, No. 1, f.o.t.	115/6
,, No. 3, f.o.t.	113/-
Cleveland No. 3, Glasgow	107/-
,, ,, Falkirk	104/-
Scottish hem. M/Nos. d/d	123/-*
Sheffield (d/d district)—	
Derby forge	100/6
,, fdry. No. 3	103/6
Lincs forge	100/6
,, fdry. No. 3	103/6
W.C. hematite	128/6*
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	109/-
Staffs fdry. No. 3	109/-
Northants fdry. No. 3	107/6
Cleveland fdry. No. 3	109/-
Glengarnock, No. 3	137/6
Clyde, No. 3	137/6
Monkland, No. 3	137/6
Summerlee, No. 3	137/6
Eglinton, No. 3	137/6
Gartsherrie, No. 3	137/6
Shotts, No. 3	137/6

* Subject to a rebate of 5s. per ton under certain conditions.

FINISHED IRON AND STEEL

Usual district deliveries.

[A rebate of 15/- per ton for steel sections, plates and joists is obtainable in the home trade under certain conditions.]

Iron—	£	s.	d.	£	s.	d.
Bars (cr.)				13	5	0
Nut and bolt iron	11	12	6	to 12	2	6
Hoops				14	2	6
Marked bars (Staffs) f.o.t.				15	15	0
Gas strip				14	2	6
Bolts and nuts, $\frac{3}{4}$ in. × 4 in.				17	10	0 and up.
Steel—						
Plates, ship, etc.	11	8	0	to 11	10	6
Boiler plts.	11	18	0	to 12	0	6
Chequer plts.				13	0	6
Angles				11	0	6
Tees				12	0	6
Joists				11	0	6
Rounds and squares, 3 in. to $5\frac{1}{2}$ in.				12	0	6
Rounds under 3 in. to $\frac{1}{4}$ in. (Untested)				11	9	0
Flats—8 in. wide and over				11	5	6
,, under 8 in. and over 5 in.				11	10	6
Rails, heavy				10	2	6
Fishplates				14	2	6
Hoops (Staffs)				12	4	0
Black sheets, 24g. (4-t. lots)				15	15	0
Galv. cor. shts. (,,)				19	10	0
Galv. flat shts. (,,)				20	0	0
Galv. fencing wire, 8g. plain				20	5	0
Billets, soft, 100-ton lots				7	17	6
Sheet bars				7	15	0
Tin bars				7	15	0

PHOSPHOR BRONZE

	Per lb. basis
Strip	$13\frac{1}{2}$d.
Sheet to 10 w.g.	$13\frac{1}{2}$d.
Wire	$15\frac{1}{2}$d.
Rods	$15\frac{1}{2}$d.
Tubes	$20\frac{1}{2}$d.
Castings	16d.

Delivery 3 cwt. free.
10% phos. cop. £33 above B.S.
15% phos. cop £38 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	$1/3\frac{1}{2}$ to $1/9\frac{1}{2}$
To 15 in. wide	$1/3\frac{1}{2}$ to $1/9\frac{1}{2}$
To 18 in. wide	1/4 to 1/10
To 21 in. wide	$1/4\frac{1}{2}$ to $1/10\frac{1}{2}$
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks	9d. to $1/5\frac{1}{2}$
Ingots rolled to spoon size	1/- to $1/8\frac{1}{2}$
Wire round—	
to 10g.	$1/6\frac{1}{2}$ to $2/1\frac{1}{2}$

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, $1/5\frac{1}{2}$ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	25.76
No. 2 foundry, Valley	24.00
No. 2 foundry, Birm.	20.38
Basic, Valley	23.50
Malleable, Valley	24.00
Grey forge, Valley	23.50
Ferro-mang. 80%, seaboard	102.50
O.-h. rails, h'y, at mill	42.50
Billets	37.00
Sheet bars	37.00
Wire rods	47.00
	Cents.
Iron bars, Chicago	2.40
Steel bars	2.45
Tank plates	2.25
Beams, etc.	2.25
Skelp, grooved steel	2.10
Steel hoops	2.40
Sheets, black, No. 24	3.15
Sheets, galv., No. 24	3.80
Wire nails	2.75
Plain wire	2.90
Barbed wire, galv.	3.40
Tinplates, 100-lb box	$5.35

COKE (at ovens)

Welsh foundry	42/6
,, furnace	36/-
Durham foundry	37/-
,, furnace	35/-
Scottish foundry	37/6
,, furnace	35/-

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box	25/- to 26/-
,,	28×20 ,,	51/- to 52/-
,,	20×10 ,,	36/6 to 36/9
,,	$18\frac{3}{4}$×14 ,,	26/3 to 26/6
C.W.	20×14 ,,	22/6 to 23/-
,,	28×20 ,,	46/- to 46/6
,,	20×10 ,,	32/- to 32/6
,,	$18\frac{3}{4}$×14 ,,	23/- to 23/6

SWEDISH CHARCOAL IRON & STEEL

	£	s.	d.	£	s.	d.
Pig-iron	£12	0	0	to £13	0	0
Bars-hammered, basis	£20	0	0	to £21	0	0
Bars and nail-rods, rolled, basis	£19	0	0	to £20	0	0
Blooms	£16	0	0	to £17	0	0
Keg steel	£27	0	0	to £30	0	0
Faggot steel	£20	0	0	to £25	0	0
Bars and rods dead soft st'l	£19	0	0	to £20	0	0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 19.39 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

		£	s.	d.		
July	22 ..	56	10	0	dec.	5/-
„	23 ..	56	11	3	inc.	1/3
„	26 ..	56	17	6	„	6/3
„	27 ..	56	12	6	dec.	5/-
„	28 ..	56	16	3	inc.	3/9

Electrolytic Copper

		£	s.	d.		
July	22 ..	63	10	0	inc.	5/-
„	23 ..	63	10	0	No	change
„	26 ..	63	10	0	„	„
„	27 ..	63	10	0	„	„
„	28 ..	64	0	0	inc.	10/-

Standard Tin (cash)

		£	s.	d.		
July	22 ..	264	10	0	dec.	40/-
„	23 ..	262	10	0	„	40/-
„	26 ..	264	10	0	inc.	40/-
„	27 ..	262	15	0	dec.	35/-
„	28 ..	262	0	0	„	15/-

Tin (English ingots)

		£	s.	d.		
July	22 ..	264	10	0	dec.	62/6
„	23 ..	262	10	0	„	40/-
„	26 ..	264	10	0	inc.	40/-
„	27 ..	262	15	0	dec.	35/-
„	28 ..	262	10	0	„	5/-

Spelter (ordinary)

		£	s.	d.		
July	22 ..	22	5	0	dec.	7/6
„	23 ..	21	18	9	„	6/3
„	26 ..	22	13	9	inc.	15/-
„	27 ..	22	7	6	dec.	6/3
„	28 ..	22	15	0	inc.	7/6

Spelter (Electro, 99.9 per cent.)

		£	s.	d.		
July	22 ..	24	17	6	dec.	6/3
„	23 ..	24	10	0	„	7/6
„	26 ..	25	6	3	inc.	16/3
„	27 ..	24	18	9	dec.	7/6
„	28 ..	25	6	3	inc.	7/6

Lead (soft foreign, prompt)

		£	s.	d.		
July	22 ..	23	2	6	dec.	12/6
„	23 ..	23	3	9	inc.	1/3
„	26 ..	23	7	6	„	3/9
„	27 ..	22	13	9	dec.	13/9
„	28 ..	22	13	9	No	change

Lead (English)

		£	s.	d.		
July	22 ..	25	5	0	dec.	10/-
„	23 ..	25	5	0	No	change
„	26 ..	25	5	0	„	„
„	27 ..	24	10	0	dec.	15/-
„	28 ..	24	10	0	No	change

AVERAGE MONTHLY PRICES OF UNMARKED BARS (SOUTH STAFFS)

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1902	7 0 0	6 10 0	6 15 0	6 15 0	6 15 0	6 10 0	6 10 0	6 15 0	6 15 0	6 15 0	6 10 0	6 10 0	6 13 4
1903	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 7 0	6 5 0	6 9 4½
1904	6 5 0	6 5 0	6 5 0	6 5 0	6 10 0	6 5 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 2 11½
1905	6 5 0	6 5 0	6 0 0	5 17 6	5 15 0	5 15 0	5 15 0	6 0 0	6 0 0	6 5 0	6 15 0	6 15 0	6 1 10
1906	7 0 0	7 5 0	7 5 0	7 5 0	6 17 6	6 15 0	6 12 6	6 10 0	6 10 0	6 12 6	6 16 3	7 3 9	6 17 8
1907	7 3 9	7 5 0	7 5 0	7 5 0	7 5 0	7 7 6	7 5 0	7 7 6	7 7 6	7 7 6	7 7 6	7 5 0	7 5 11
1908	7 2 6	7 0 0	7 0 0	7 0 0	6 15 0	6 7 6	6 5 0	6 2 6	6 2 6	6 2 6	6 2 6	6 0 0	6 10 0½
1909	6 0 0	6 0 0	6 0 0	5 17 6	6 0 0	6 0 0	6 0 0	5 17 6	6 0 0	6 2 6	6 2 6	5 17 6	5 19 9
1910	6 2 6	6 3 4½	6 7 6	6 7 6	6 7 6	6 7 6	6 6 6	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 7
1911	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 10 0	6 12 6	6 16 6	6 7 6
1912	6 18 9	7 1 10	7 2 6	7 8 9	7 18 0	8 0 7	8 2 6	8 3 6	8 5 0	8 6 3	8 7 6	8 8 9	7 17 0
1913	8 11 6	8 10 7½	8 10 0	8 8 1½	8 2 0	8 0 0	7 17 6	7 11 6	7 8 9	7 5 6	6 18 1½	6 17 6	7 16 9
1914	6 17 6	6 15 7½	6 12 6	6 10 0	6 10 0	6 10 0	6 10 0	7 11 10½	8 0 0	7 12 6	7 5 7½	7 6 3	7 1 0
1915	7 11 6	8 5 11	8 8 9	9 6 0	10 3 2	10 19 2	11 12 6	11 13 1½	11 13 9	11 14 3	12 1 10½	13 0 9	10 6 0½
1916	13 7 6	13 10 8	13 12 9½	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 3 9
1917	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0½
1918	13 15 0	13 17 8	13 17 6	13 17 6	13 17 6	13 17 6	13 17 6	14 15 0	14 15 0	14 15 0	14 15 0	14 15 0	14 4 8
1919	15 10 0	16 5 0	17 15 0	17 15 0	20 15 0	21 0 0	21 0 0	22 0 0	22 0 0	22 0 0	22 7 6	22 12 6	20 1 8
1920	24 7 6	24 10 0	25 10 0	27 10 0	29 5 0	31 0 0	31 10 0	31 10 0	31 10 0	31 10 0	31 10 0	29 7 6	29 1 8
1921	26 17 3	25 0 0	23 0 0	21 0 0	19 0 0	18 5 0	16 0 0	16 0 0	15 14 0	14 0 0	13 6 8	13 0 0	19 4 5½
1922	13 0 0	12 3 9	11 14 0	11 11 10½	11 5 0	11 3 6	11 2 6	11 5 0	10 17 2½	10 16 3	10 13 0	10 12 6	11 7 0½
1923	10 16 10½	11 3 1½	12 2 6	12 8 9	12 11 6	12 1 3	11 15 11½	11 15 0	11 15 0	11 15 0	12 13 6	12 8 3	11 18 10½
1924	12 9 6	12 10 0	12 10 0	12 15 7½	12 17 6	12 17 6	12 17 6	12 17 6	12 17 6	12 14 0	12 12 6	12 12 6	12 14 3½
1925	12 12 6	12 12 6	12 12 6	12 12 6	12 12 6	12 7 6	12 7 6	12 7 6	12 4 6	11 18 6	11 13 9	11 13 0	12 6 2
1926	11 7 9½	11 5 0	11 5 0	11 5 0	11 3 9	11 3 9	11 5 0	12 0 0	13 0 0	*	15 7 6	12 19 0	12 0 2
1927	12 6 3	12 2 6	11 14 0	11 0 0	10 18 9	10 13 6	10 12 6	10 5 0	9 16 0	9 15 0	9 13 9	9 12 9	10 14 2
1928	9 12 6	9 12 6	9 11 0	9 10 0	9 8 4	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 3 6	9 1 3	9 7 0
1929	9 0 0	9 2 6	9 5 7½	9 9 4½	9 10 0	9 17 6	10 2 6	10 2 6	10 2 6	10 0 6	10 3 9	10 5 7	9 15 2½
1930	10 7 6	10 7 6	10 7 6	10 6 10½	10 6 3	10 5 0	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	10 4 7½
1931	10 2 6	10 0 0	10 0 0	10 0 0	9 18 1½	9 17 6	9 17 6	9 17 6	9 17 6	9 17 6	9 17 6	9 16 10½	9 18 0½
1932	9 15 0	9 15 0	9 15 0	9 15 0	9 13 9	9 11 3	9 10 0	9 10 0	9 10 0	9 6 3	9 5 0	9 5 0	9 10 11½
1933	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0
1934	9 5 0	9 8 1½	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 11 6
1935	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6
1936	9 12 6	9 15 0	10 2 6	10 2 6	10 2 6	10 2 6	10 6 3	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 4 5½
1937	10 10 0	10 10 0	11 17 6	11 17 6	11 17 6	11 17 6	12 4 6	—	—	—	—	—	—

* No quotation available owing to strike.

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